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THE FOUNDRY TRADE JOURNAL,
165, Strand, London, W.C.

BRITISH FOUNDRYMEN'S ASSOCIATION.

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NOTES AND COMMENTS.

Crucible Steel Making.

The utlimate fate of the existing method of crucible steel making has recently been the subject of considerable discussion, chiefly waged through the Press associated with Sheffield. The advocates of gas-fired crucible furnaces have pitted their opinions against those of the coke-fired furnace school, expressing their views and preferences very strongly. Finally come those who maintain that the electric furnace is destined to hold the field at an early date. In connection with the question, "Is crucible steel making to decay?" Mr. W. H. Dyson, managing director of the Amalgams Company, Limited, contributes the following opinions to the discussion:—

"In our opinion," he says, "the crucible steel furnace as we have it to-day will ultimately disappear, and undoubtedly be superseded by the electric furnace. Sheffield is not in any way behind its Continental neighbours in the matter of electric smelting. The process is just issuing from the experimental stages, and no town or country can fairly claim to be leading the way, unless it be Sheffield.

"We believe that both Krupps and the John Cockerill Company are adopting the Girod's system of furnace, which is of the resistance type, but is, in our opinion, superior to other forms of resistance furnaces, in that the current passes directly through the bath; the second electrode being in the hearth of the furnace itself. We, as a city, are interested because we have most to gain, but it may also be said that we have most to lose, should we abandon an old and tried system for a new one whose value was not fully established. The new furnace may be for the future—we think it is—but as business men we want to know something about it before accepting it as an essential item of steel works' equipment."

In a paper read before the Iron and Steel Institute last month, Professor B. Igewsky, describing "A New Type of Electric Furnace for the Smelting of Iron," stated that with a supply of electrical energy at a cheap rate, the electric furnace should be capable of producing steel more cheaply than by the open-hearth process; the crucible steel process, which is becoming obsolete, he continued, may be excluded as a method for the production of steel on a commercial scale.

That the electric furnace will ultimately supersede the older methods appears quite probable; at the same time, the coke-fired furnace is well established, and with the record of past successes, and the prejudice in its favour which is strong in many quarters, it will die hard.

Technical Societies and Lecturers.

A paper read before the West of Scotland Iron and Steel Institute on "The Production of Malleable Castings by the Fusion of Wrought Iron in Crucibles," which we publish on another page, met with some comments of dissatisfaction in the course of the discussion which followed the reading. The complaint voiced by several members was that the author, while claiming for the process he described things which, if true, would prove of inestimable service to the trade, did not give the necessary particulars to enable others to establish the value of process for their own benefit.

Certainly at first sight it appears quite reasonable to expect that a paper read before an institution devoted to the interest of the iron and steel trades, should contain the fullest information for the benefit and assistance of the members. But a rather delicate point is raised, and one which has occurred before. An inventor may possess the knowledge of a process or an invention by which certain trades would greatly benefit, and he may be willing (perhaps partly in his own interests) to communicate sufficient information to arouse attention and enquiry; a technical institution is in that case a handy medium. In the case in point it was objected that as the author had omitted to give particulars of certain essential features of his process —to wit, the exact nature of the additions to the metal—the paper was not worth serious consideration. The point is this: Do the claims of such an institution and the reading of a paper before it make it incumbent on the author to reveal particulars of what may be of considerable commercial value to himself? To direct attention to the existence of any trade improvement is in itself a desirable thing; and under some conditions the author having explained in principle his process, is justified in retaining certain particulars, leaving those interested to place themselves in communication with him in the ordinary way of business. On the other hand, if such a process be properly protected, there should be no harm in giving the fullest information, particularly when the process is placed so definitely before the public. If the author is permitted to impose any severe limitations on the information he gives, it will require a very nice discrimination on the part of those introducing lecturers and subjects to prevent the technical society's platform becoming a cheap advertising ground for commercial quacks.

British Foundrymen's Association.

The Secretary of this Association announces that the next annual meeting will be held at Newcastle-on-Tyne, on August 4, 5, and 6.

The Franco-British Exhibition.

The Exhibition at Shepherd's Bush is now open to the public and receiving enormous patronage, as it deserves to do. One of the most prominent centres of interest to technical men is the Machinery Hall, a building covering about six acres of ground. There is a variety of machinery displayed, and while there is not much in the way of foundry equipment, there are many magnificent exhibits of cast iron and steelwork which are sure to take the attention of visiting foundrymen. The prominent firms in our iron- and steel-producing and working trades are well represented.

A very interesting stand is situated in the centre of the French section; it represents the Pont à Mousson Founderies of Meurth and Moselle, one of the largest producers of pig-iron and castings in France. One of this concern's largest products is cast iron pipe, of which they produce 80,000 tons annually. We hope to deal more fully with this stand in a later issue, for the information contained in the charts and diagrams exhibited thereon is very interesting, particularly in view of the position in the iron trade held by the firm.

At present there is much to be done before the Machinery Hall is ready, but a visitor would be well repaid by a visit to this section of the Exhibition alone.

THE INSTITUTE OF METALS.

In previous issues we have published particulars of the proposal to form a technical association of manufacturers of non-ferrous metals, on the lines of the Iron and Steel Institute. In accordance with the decision arrived at during the Manchester meeting of those interested, held last March (see April FOUNDRY TRADE JOURNAL), a further meeting is to be held on Wednesday, June 10, in London. A letter from Mr. W. H. Johnson, of Messrs. Richard Johnson, Clapham & Morris, Limited, states that by the kind permission of the Institute of Mechanical Engineers, the proposed conference will be held at 2.30 p.m. on June 10, at the Institute of Mechanical Engineers, Storeys Gate (close to St. James's Park Station), Westminster. All those who are interested in the manufacture or use of brass, copper, lead, zinc, aluminium, nickel, gold and silver—in fact, in the non-ferrous metals and their alloys, are earnestly requested to attend. The membership of the proposed Society will be open to all practical and scientific men at home and abroad. Already letters have been received from manufacturers and metallurgists in France, Germany, Sweden, the United States, and other countries desiring to join the proposed Society.

Professor Hoffman, of the Massachusetts Institute of Technology, replying to Professor Carpenter, of Manchester, says:—

"I beg to express my interest in the new undertaking. The impetus that the study of metals and alloys has received by the application of the laws of physical chemistry is so great that it seems very desirable to have a Society which represents the non-ferrous metals and their alloys. I hope that, following the example of the Iron and Steel Institute, your publication will give not only original papers, but make it a point to cover everything that is being done the world over, in the form of abstracts. Thus a person seeking to find some information upon non-ferrous alloys need only turn to your 'Proceedings' and be sure to find it recorded there."

The proposed Institute, to be called the Institute of Metals, is receiving the support of many members of prominent firms of shipbuilders and marine engineers, as well as the following trades:—Copper smelters, copper wire drawers, copper and brass tube makers, general copper and brass manufacturers, copper and brass founders, nickel rollers, aluminium smelters, gold and silver refiners, white lead manufacturers, silver and electroplate manufacturers, boiler makers, cycle and motor makers, cutlers, electric cable makers, electrical manufacturers, engineers, marine engineers, shipbuilders, etc.

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FOUNDRY PLANT AT THE DEUTZ GAS ENGINE WORKS.

E. NEUFANG (Stahl und Eisen).

FROM small beginnings the Deutz Gas Engine Works, at Deutz, near Cologne, have grown into an undertaking of world-wide celebrity, and their products have increased in number and variety, so that whilst continuing to build small machines, they have taken up the manufacture of those of larger dimensions, including, latterly, the Diesel motor. The foundry, which was started in 1872, has kept pace with these developments, and is now one of the largest in the Rhineland district. In addition to turning out parts for small gas engines in large quantities, this part of the establishment has to comply with the requirements of the works in respect of castings for the large engines, which castings must be of the highest quality attainable. The description of the extension and equipment of this foundry will awaken particular interest when it is remembered that the task of improving the foundry, so as to keep pace with the needs of the establishment from time to time, has been accompanied with difficulties resulting from lack of space, and necessitating frequent reconstructions.

The accompanying plans, Figs. 1 and 2, enable a comparison to be made between the size of the foundry in 1872 and 1900, the extensions during that period being indicated in Fig. 2, by the hatching. The size of the foundry at the present day is shown in Fig. 3 (plan), from which it will be seen that the spacious hall illustrated in Fig. 4 has been formed out of six rooms, by the demolition of over 200 yards of walls. The reconstruction has been carried out in such a manner that both the crane tracks and the roof are carried on rolled steel pillars, thus affording plenty of light, whilst efficient ventilation is provided by the erection of a large number of draught flues, projecting about 13 ft. above the roof. Since

1872, the superficial area of the foundry has been increased from about 13,600 square feet to 64,500 square feet of working space, including the moulding and core shops and drying ovens. The

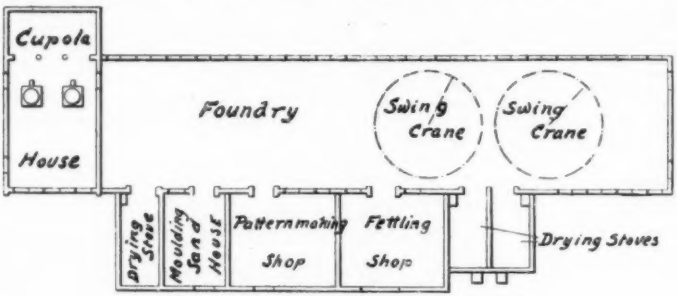


FIG. 1.—PLAN OF THE FOUNDRY IN 1872.

total area occupied by buildings, including the cupola furnace house, moulding sand department, fettling shop, engine house, sheds, etc., is now over 96,000 square feet. The internal reconstruction of the foundry dates from the assumption of the management by the author in 1901, since which time the development of the large gas engine trade has necessitated the production of larger and heavier castings, and, therefore, the employment of different appliances from those formerly in use.

In 1900 the output of the foundry was 5,948 tons, whilst at present it has grown to 12,500 tons; that is to say, the production of finished articles has more than doubled in seven years. This rapid increase is partly explained by the fact that the weight of the castings has been greater since the building of large gas engines and gas generators was undertaken; but, in the main, the increase is due to the adoption of new appliances and to the reconstruction of the foundry, as may be seen from the graphic statistical table given in Fig. 5.

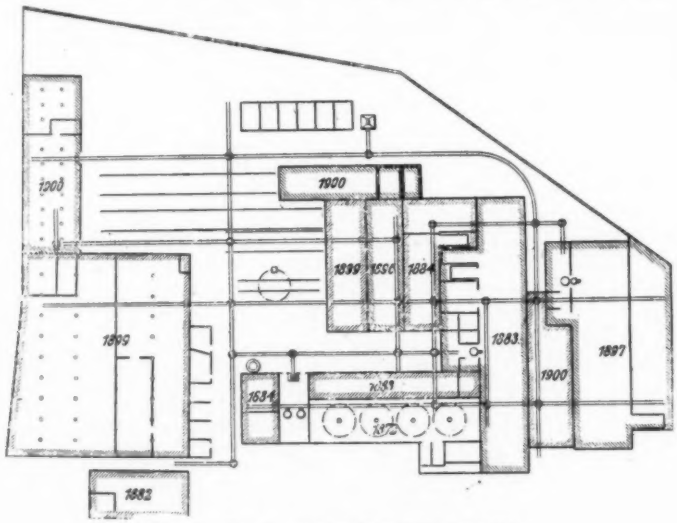


FIG. 2.—PLAN OF THE FOUNDRY IN 1900.

In 1900, the output per man per hour was 13.68 lbs., but now the reconstruction is completed, it has risen to 19.8 lbs., an increase of 46 per cent. The outlay on wages per cwt. of finished castings has declined from 3.16 marks (shillings) to 2.80 marks, namely, by 16 per cent., whilst at the same time the average earnings per head of the working staff per hour has increased from 40½ pf. (5d.) to 53 pf. (6½d.), or by 32 per cent.

The following additional particulars will give a better idea of the productive capacity of the foundry. About 15 lbs. of castings per day are produced for every 10 square feet of moulding space; that is to say, about 4 cwts. for each moulder engaged, or nearly 2 cwts. per head of the whole number of workmen employed.

With the growth of the foundry it has been found necessary to alter the position of the sand department, fettling shops, workshops, etc., at frequent intervals, bearing in mind during reconstruction that room must be left for future extensions of these departments. This is especially the case with the sand department and the fettling shops.

The sand house has now reached its permanent location, the position of which is denoted by 7 on the plan (Fig. 3), and for the last two and a half years has been fitted up with automatic appliances, so that, after the sand has been shovelled in, all further treatment is performed by mechanical means, up to the delivery of the finished sand into the storage bunkers; (see the plans and sections in Figs. 6, 7, and 8, and also the views in Figs. 9 and 10).

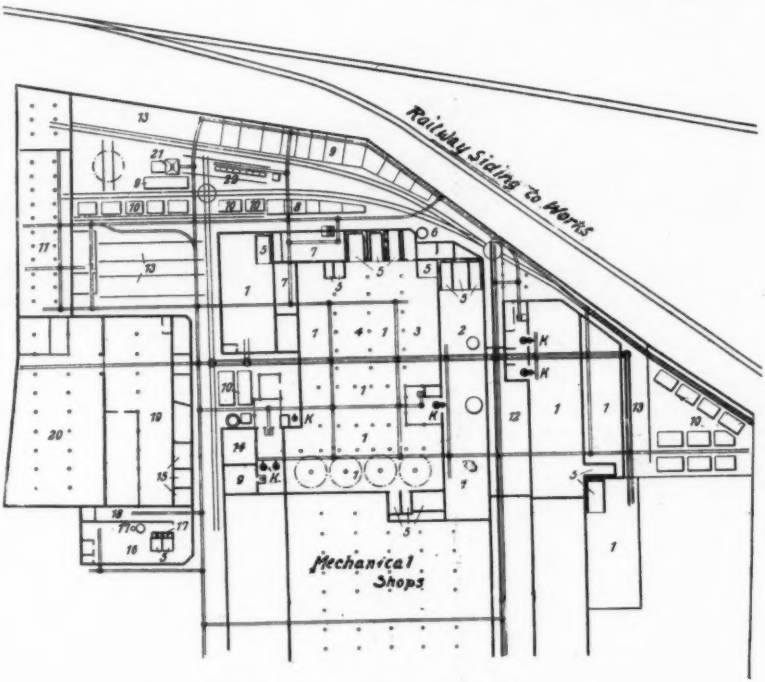


FIG. 3.—PLAN OF THE FOUNDRY IN 1908.

In the sand house, the sand discharged from the railway trucks into the sheds in front, is carried in small rail tubs to the elevator 1, which takes it up to the first floor and delivers it into a jig conveyor 2. This forwards it into one or other of the mixing troughs 3 or 4. The old sand is shovelled into the elevator 5, which raises it on to a jig screen 6; and

after being screened and passed through an electro-magnetic separator, 6*a*, for removing iron, it is raised by an elevator 7 into the jig conveyor 8, discharging it into the mixers 3 and 4. The coal dust is shovelled into the elevator 9, and carried by worm conveyors to the coal-dust bunkers 10 and 11, situated directly above the mixing troughs, into which latter the coal dust is delivered by sliding down a distributing roller. In this way the mixers are charged with old and fresh sand and coal dust in the proportions in which these are shovelled into the elevators on the ground floor. After a thorough mixing, the contents of the mixing troughs are conveyed to the feed hopper of the disintegrator mills, 12 13, which loosen the sand in the well-known manner and allow it to fall down into the finished sand bunkers, 14 and 15, underneath.

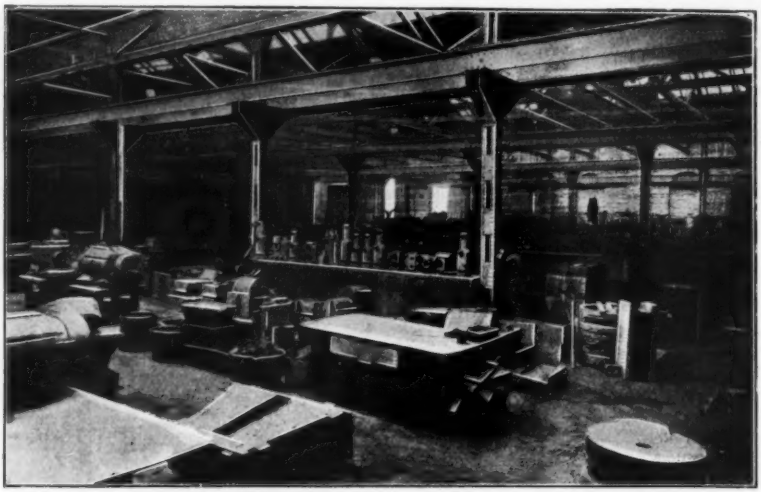


FIG. 4.—LARGE HALL FORMED BY RECONSTRUCTION.

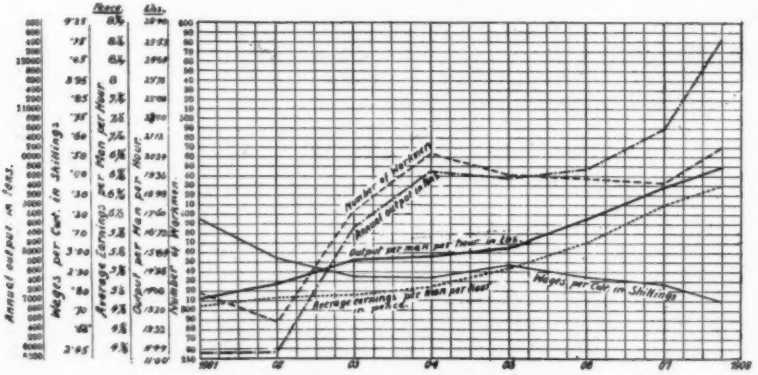
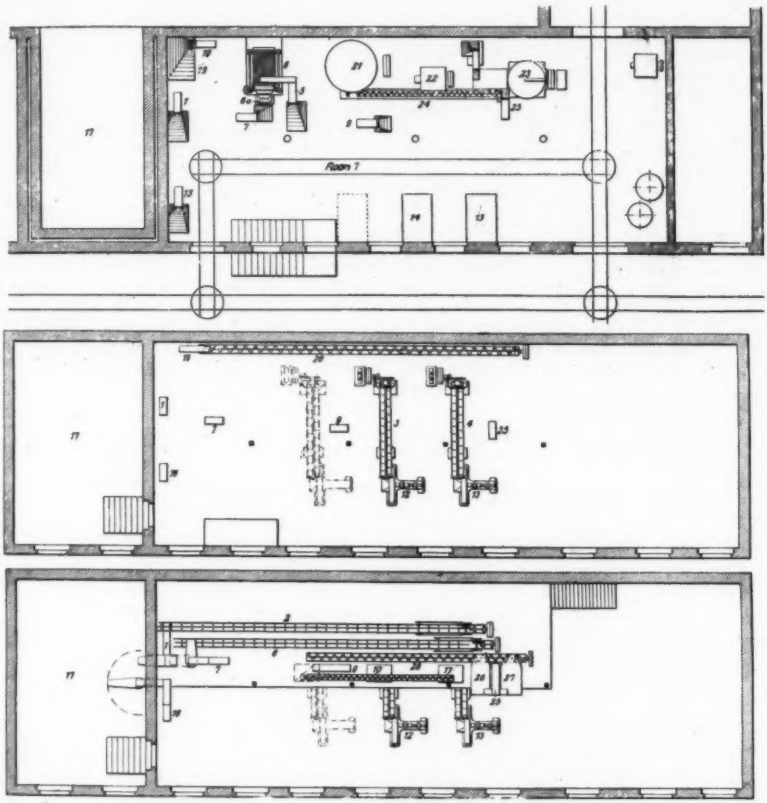


FIG. 5.—GRAPHIC STATISTICAL TABLE.

The above is the treatment applied to sand that is to be used in the state in which it comes from the pit, whereas the sand that has to be ground and dried for making moulds for finer and moulding-machine castings is treated in the following manner :—The fresh sand is brought to the elevator 16, which raises it to the drying floor 17, where it is spread out. This drying floor is formed by removing sand 10 in. deep, in the course of a night. The dried sand is pushed into the bunker 18, and then raised by an elevator 19 to the first floor, where it is forwarded by the worm conveyor 20 to the edge runner mill 21, ball mill 22, and edge runner mill 23, for grinding. These three mills discharge the sand into a common worm conveyor 24, in the floor, and from this it is raised by the elevator



FIGS. 6, 7, & 8.—SAND PREPARING HOUSE.

1, Elevator. 2, Jig Conveyor. 3 and 4, Mixing Troughs. 5, Elevator. 6, Jig Screen. 6a, Magnetic Iron Separator. 7, Elevator. 8, Jig Conveyor. 9, Elevator. 10 and 11, Coal Dust Bunkers. 12, Disintegrator. 14, Bunker for Finished Sand. 16, Elevator. 17, Drying Floor. 18, Sand Bunker. 19, Elevator. 20, Worm Conveyor. 21 and 23, Edge Runner Mills. 22, Ball Mill. 24, Worm Conveyor. 25, Elevator. 26 and 27, Storage Bunkers. 28, Worm Conveyor.

a portion of the drying stove arches underneath, and mounting an iron flooring, supported by girders, about 1 ft. above the arches. The heat from the drying stoves flows through the intervening space, and will dry a layer of sand 10 in. deep, in the course of a night. The dried sand is pushed into the bunker 18, and then raised by an elevator 19 to the first floor, where it is forwarded by the worm conveyor 20 to the edge runner mill 21, ball mill 22, and edge runner mill 23, for grinding. These three mills discharge the sand into a common worm conveyor 24, in the floor, and from this it is raised by the elevator 25 to the storage bunkers 26 and 27. By means of adjustable slides, the sand is delivered from these bunkers into a worm conveyor 28, which transports it to the mixing troughs 3 and 4, where it is moistened, mixed with used sand and

coal dust and treated in the manner described above. The plant works admirably, and is free from dust. It was constructed from the plans of the Deutz Company, by the Badische Maschinenfabrik & Eisengiesserei, of Durlach. Up to 30 tons of moulding sand can be treated per diem, only three men being required. The proportions of the mixture being always the same, and the supply of coal dust being capable of accurate regulation by means of the mechanical feed, the moulding sand is of excellent and uniform quality. There are also three pug mills for loam, a disintegrator mill for core sand, a coke mill, and a graphite mixing machine. To save moulding sand, each moulder only receives the exact quantity marked on the ticket given him by the foreman.

Turning to the work of the foundry, the pig-iron coming into the works is piled up in wagon loads, each pile being marked with a serial number. Samples are drawn from the heaps and analysed in the well-equipped works laboratory by the usual standard methods. The coke and limestone are also analysed, and a set of electrolytic apparatus for metal analysis is also available. The pigs are broken in an electrically - operated breaker, which can be run on rails into position before the different heaps. The various heaps are drawn upon for use in accordance with the results of the analyses, special instructions with regard to each heap being handed to the foreman.

The scrap iron is classified into two grades, according to origin and thickness. No pipe or pot scrap is used, and no outside scrap at all for the best work. All the materials are kept apart carefully, cleanliness and order being insisted on throughout the works.

The foreman melter has to supervise the melting and weighing-out of the charges, and to see that the necessary sample pieces for the percussion and bending tests are cast, in all grades, every day, and that these pieces are sent to the testing shop (see later) the next day. In the case of all large and important castings, such as cylinders, bearing standards, pump bodies, etc., extra pieces, measuring $1\frac{1}{2}$ to $4\frac{1}{2}$ in. diameter, are cast for the bending test. It is only by this constant control—which is somewhat expensive—that it is possible to ascertain whether the prescribed charge furnishes the desired quality of iron, and to keep the materials properly classified on the basis of analysis—a point of extreme value in connection with gas-engine castings. A number of average results of the daily tests are given in the appended table.

Table showing average results of daily tests.

Grade No.	Analyses.							Bending strength.			
	Total C.	Combined C.	Graphitic.	Si.	Mn.	P.	S.	Diam. of Test Bar, mm.*	Deflect on per 1,000 mm. of free length mm.	Bending strength, lb. per sq. in.	Contraction. Per cent.
1	3.60	0.30	3.30	2.3	0.6	0.7	0.10	30	13	48,357	0.09
2	3.40	0.45	2.95	1.8	0.7	0.7	0.10	50	12	45,513	1.05
3	3.50	0.50	3.00	1.5	0.5	0.1	0.08	30	23	54,046 to 56,890	1.10
4	3.20	0.60	2.60	1.2	0.7	0.1	0 08	40	20	51,202 to 54,046	1.05
5	3.00	0.90	2.10	1.3	0.8	0 6	0.10	40	15	56,890	1.35
6	2.90	1.10	1.80	1.0	0.9	0.6	0.10	50	14	55,469	1.35
7	3.25	0.85	2.40	1.4	0.5	0.15	0.08	30	22	59,736	1.25
8	3.10	0.90	2.20	1.2	0.7	0.15	0.08	40	20	55,469	1.25
9	3.00	1.00	2.00	1.0	0.8	0.15	0.08	60	15	61,158	1.20
10	3.50	0.30	3.20	1.8	0.6	0.5	0.10	20	18	54,046	1.03
11	3.40	0.40	3.00	1.5	0.6	0.3	0.10	30	16	51,202	1.12
12	3.00	0.45	2.55	1.7	0.8	0.4	0.08	25	22	48,357	1.03
13	3.30	0.30	3.00	2.0	0.7	0.6	0.10	40	12	54,046	0.95
14	3.20	0.60	2.60	1.8	0.7	0.8	0.10	60	12	52,624	1.15
15	3.10	0.80	2.30	1.5	0.7	0.8	0.10	80	10	49,780	1.10

* The diameters of the test bars correspond to the mean thickness of metal in the castings.

The iron is melted in five cupola furnaces, three of them being fitted with fore hearths and two without (Fig. 11). A small tilting cupola furnace is also present, but is used exclusively for ex-

perimental meltings and melting grades intended for special castings. The height of these furnaces, from the base to the charging mouth, varies from 14 to 19 ft. The escape of sparks and ash is prevented by the use of large spark chambers fitted with water sprays. The blast pressure is maintained at $23\frac{5}{8}$ in. water-gauge, and the blast is produced by electric fans. The furnaces have two rows of tuyeres, and the ratio of the tuyere apertures to the internal diameter of the cupolas is about 1.3. To get the fore-hearth very hot at the commencement of melting, the top valve is opened, so that the flame from the cupola furnace passes into the fore-hearth and warms it up thoroughly. The amount of limestone used in the charge is about 3 per cent., and about 4 to 5 parts of slag are obtained per 100 of charge. The slag is drawn off into tubs let into the floor and containing a cast-iron plate with a cast-on hook, by means of which latter the cooled slag is lifted out as a solid lump, and can be taken away quickly.

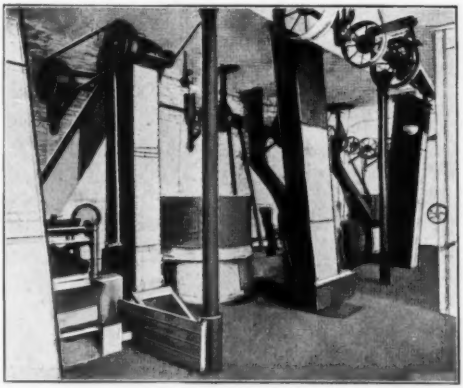


FIG. 9.—GROUND FLOOR OF SAND-PREPARING HOUSE.

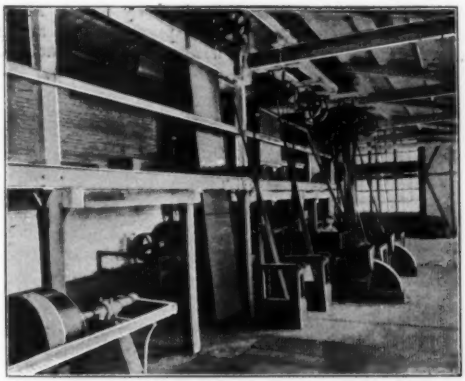


FIG. 10.—SAND-PREPARING HOUSE (FIRST FLOOR) WITH MIXING TROUGHS, DISINTEGRATOR MILLS, COAL DUST ELEVATOR AND BUNKER.

An unwelcome accompaniment of cupola work is the formation of slag wool, which is produced when the thinly-fluid slag is

expelled with the full blast. Part of the blast air escapes through the tap hole, and blows the fluid slag into very fine

slag without air pressure proved a hindrance to the work of the furnace; but an arrangement has been recently

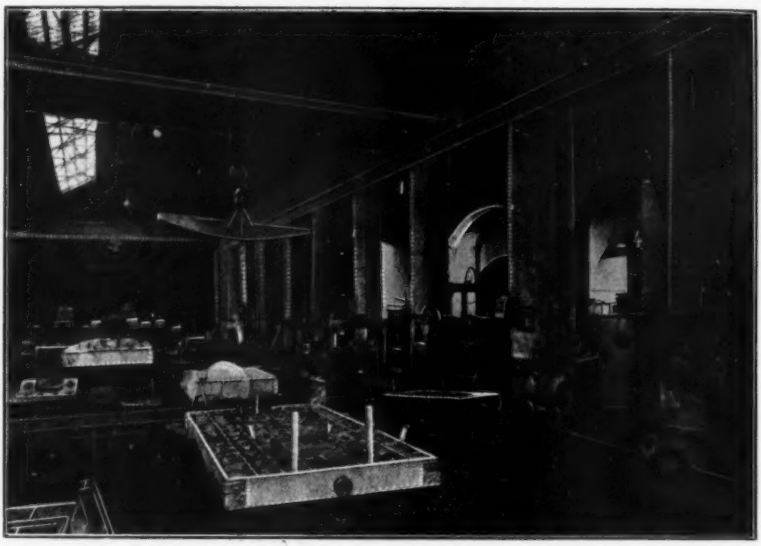


FIG. 11.—VIEW OF FOUNDRY FOR HEAVY CASTINGS, WITH CUPOLA FURNACES 4 & 5.

threads, which fly about in the room and are a source of great danger to the workmen's lungs. Numerous experiments

devised by means of which the slag can be tapped without stopping the blast and without the production of this wool.

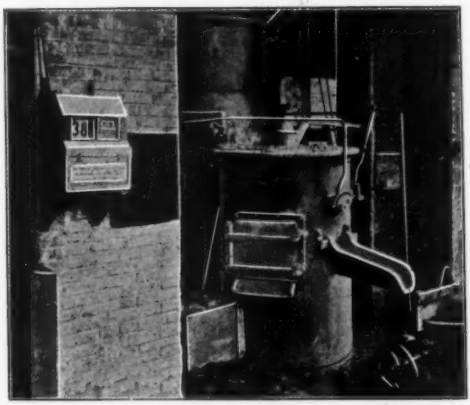


FIG. 12.—CHARGE INDICATOR.

have shown that slag wool is formed whether the slag is acid or basic in character. Attempts made to tap the

Great care is bestowed on the lining of the furnaces, especially in order to maintain the original diameter of the

furnace, because the working aperture of the tuyeres is designed to suit that diameter only, so that the most refractory iron can be worked with a minimum consumption of coke. The inner layers of lining are of acid brick.

The arrangement of a daily working plan is an important matter in working cupola furnaces. For this purpose sheets are provided, containing particulars of the various grades in serial order, with the name of the man entrusted with the pouring of the iron. The working is also checked by means of charge indicators, stating the number of charges fed into the furnace and also the class of iron that is being discharged at any time (see Fig. 12). Though, at first sight, there would not seem to be any need for these indicators, they nevertheless facilitate supervision by the foundry manager and pourers, especially in a foundry like the present, where only high-class castings are produced, and where the pieces weigh from 1 lb. to 48 tons, as many as 8 to 10 different grades being sometimes required in a single day. The pourer can see from a distance whether the iron running out of the furnace is the right sort for the casting on which he is engaged, and by this means the production of wasters, to be rejected on account of the unsuitable character of the metal, is prevented.

(To be continued.)

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A PETITION has been presented for the compulsory winding-up of the Globe Gas Engine Company, Limited, Johnstone.

ALLEGED BREACH OF CONTRACT.—At the West Bromwich County Court, recently, his Honour Judge Smith heard an action by Messrs. S. B. Dickinson & Sons, iron and steel merchants, West Bromwich, against William Jones & Sons, Limited, ironfounders, Cecil Street Foundry, Birmingham, to recover £37 16s. 2d. damages for alleged breach of contract. Plaintiffs contracted to sell the defendants 50 tons of cast-iron scrap and 50 tons of pig-iron, but before the deliveries were finished defendants cancelled the balance of both orders. The defendants contended that plaintiffs had not delivered the goods within a reasonable time, and therefore they were entitled to cancel the agreement. His Honour gave judgment for the plaintiffs for the full amount claimed.

BRITISH FOUNDRYMEN'S ASSOCIATION.

Birmingham Branch.

NOTES ON CONTRACTION.

(Continued from page 262, May.)

The practice of baring or stripping certain parts of castings while still in a very hot condition is followed with great advantage in many instances, as in cases when these castings bend or have a liability to fracture easily if left to cool in the usual manner. It will be asked, regarding the castings that bend, "Why not camber the pattern?" But when there are only a few castings wanted from that pattern it would not pay to go to that expense; as to the ones that break readily, the design of the pattern may be perfectly suitable, but defective in relation to equal cooling. If baring was not resorted to in this instance something would have to be sacrificed, either the suitability of the design or the stability of the casting. The process of baring may seem easy and simple to the uninitiated eye. It is only the exposure to the atmosphere of the slowly cooling parts of a casting, by the removal of the sand from them; but there is a certain amount of skill required, and a good deal of thought as to the time of exposure, because if a part is bared too early, it will cool too quickly, causing a defect quite as bad as the one that has been prevented by the baring, although of an opposite nature. If the part be exposed too late it will not have the desired effect. When I say too late, I don't mean that the baring has been left until the casting is nearly cold, as I have found that a casting can be treated in this way while still very hot, and no beneficial effects obtained. This brings me to the point as to what is the lowest temperature which a casting may be at, for baring to have the desired effect. I got a straight pattern, the castings from which took on a good deal of bend, and made a few experiments. In the case of the first one a very small portion was exposed as soon as the metal had solidified, with the result that the casting came out straight.

The second was left two minutes longer before baring, but a larger area was exposed, with the same result as the first instance, and so on until the baring was left till the casting became a dull red, when it seemed to have less effect, as the castings then came out with a slight bend. This bend increased until the baring was

left till the castings were a very dark red, the red being hardly perceptible. A large area was then exposed, with the result that the light and heavy parts of the casting reached the atmospheric temperature at about the same time, but this had no good effect, the bend being as great as if it had not been treated at all.

The conclusion to be drawn from these experiments is that the effects of unequal cooling in relation to the ultimate bend in a casting when cold, are confined to certain limits of temperature. We are told by scientific authorities that grey cast iron passes at once from the fluid to the solid state, there being no pasty stage as in the case of wrought iron; but even when solid at a comparatively high temperature, the metal must be in a very different state to that which it is in when cold, as the molecules or crystals must be free to re-arrange themselves, or we would not get the good effects the baring produces. Take the case of a casting in the shape of a heavy bar, with a light wing on either side, these wings bending considerably. Let us imagine it in the mould a moment or so after being cast. The light wings will have become solid, but not so the bar in the middle. The wings at once take on some of their contraction, and in so doing must alter their original positions in relation to the bar. The bar will not contract at all in its length while fluid, and there will be no cohesion between the wings and it. But when the bar solidifies, it and the wings become firmly attached in the positions they hold to one another. As at the time of attachment the bar has to contract more than the wings, the latter are crushed towards the end of their cooling, thus causing them to bend.

This crushing force, however, can be, and is, eliminated together by baring the bar at the right temperature. The direct effect of the baring must be then to hurry forward the contraction of the bar, making it contract a little more quickly than the wings, so that it may regain the position it occupied in relation to them at the time of casting. Now this alteration of position does not take place until after the casting is solid, and when the process has been performed with success, no signs of tearing or rupture are visible.

The metal must be in a state which allows great freedom of movement to its particles. This state is confined to limited temperatures. Therefore, as has been shown, to obtain perfect success in this process, the baring must be so timed that the bar will have regained its original position just at the temperature at which the freedom of movement of the particles is stopped, because, if cooled too quickly, the bar will overstep its original position before the right temperature is reached, and cause a defect just the opposite to the one it is wished to prevent. If cooled too slowly it will not have time to regain its position before that temperature is reached. I do not pretend to say that anyone can so gauge the time of baring that perfect success may be assured, as there is little to guide one except experience in the practice, and any slightly altered conditions in moulding will have effect on the inequality of cooling. In the case of the casting I mentioned before, it being the same as I illustrated the baring with, as to the heavy centre bending the edges and the edges bending the centre, this statement, on the face of it, seems rather paradoxical, as for the centre to bend the edges, it must exert a crushing force, which it cannot do until it has solidified, and the edges being crushed would put a tensile stress on the centre. The explanation of this is, when the centre has become solid, the edges have already taken on a lot of their contraction, and the centre then contracting crushes them so that they bend, this bending taking place while the centre is still very hot and to a certain degree ductile. The junction between the light and heavy parts being very clearly defined causes a sharp bend quite close to the heavy bar. This bend occurring while it is in a slightly ductile condition, draws the bar up with it. That the bar was bent while in this condition may be proved by breaking off the wings; the centre will then be found to have taken a permanent set, but not so the sides, as they will spring back, the bend left on them being accounted for by their own unequal cooling.

One point that may be noticed in this instance is, that although the metal may be slightly ductile at this high temperature, its cohesive properties are good, or it would not withstand the outward pushing force of the crushed edges.

Another example I saw a short time back similar to this. A plate, 3 ft. 6 in. long, had been made, the body of the runner to it being its full length and connected by sprays. The runner was bent, this being the result of cooling before the plate, and in bending, it had drawn the edge with it. When tried with a straight edge, before the runner was broken off, it showed more than a quarter of an inch bend, but when the runner was taken off it sprung back quite straight. The difference was due to the bending of the runner not taking place until the temperature of

the plate had been reduced to, or below a level at which the metal forming it was perfectly stable, it, therefore, being unable to take on a permanent set as in the case of the bar.

We now come to the matter of breaks. Anyone practiced at it can, by viewing a broken casting which has shown a liability to fracture on receiving a light blow, tell at a glance where and how to alter the pattern, so that it may be cured. Breaks and rents are caused by the opposition of the two stresses, crushing and tensile, as is the case in bends, but in the majority of instances the action is the inverse.

Usually it is the tensile strength of one part of a casting overcoming to some degree the crushing strength of another part which causes a bend, but in the case of breaks it usually is the crushing strength overcoming the tensile strength.

The liability to fracture is most frequently found in those castings which are of defective design or offer a great resistance to bending.

I had a very good example of a break caused by the centre of a casting cooling more quickly than the outside edges.

It is characteristic of a break caused by this inequality of cooling, that it always remains open at the edge and cannot be closed without exerting great force, and in most cases without smashing. It is as if the border of the casting were too short, and had been stretched to what was required of it, but in the stretching process had broken, springing back to its original length and leaving a gap. It is not really the case that the border is too small to enclose the centre, as it filled its position quite comfortably when the metal was introduced into the mould. The defect in the casting is due to the alteration of the relative positions of the edges and centre during the process of cooling.

This is a class of break frequently met with, and to cure it heat must be given to the centre by adding weight there, or some of the heat taken from the edges by lightening them; not as is done in many instances, adding weight where the casting is broken, as this only puts greater stress on the casting. Before adding or taking weight from any part of the casting, it should be ascertained whether the inequality has not been caused by heavy or misplaced runners.

The opposite kind of break to this is one in which the centre of the casting cools slower than the edges. This is less frequently met with, and the fracture will not be caused by any light blow.

I might illustrate this break by the heavy bar and wings casting; here we have the edge bent by the later contraction of the middle bar, and if I could manage to crack one of the wings from its edge to its junction to the centre bar, then pull the edges of the crack asunder, when I let go they would overlap one another, the bend on the edge being reduced. This kind of break is seldom seen except on very light castings of good size. More often than not when the balance of the casting is in this state, a rent or break right across is the result.

An exception to the rule in breaking may be obtained by modifying the grating and border casting. If the border be thickened and something be done to keep it from bending when crushed, it would not break like the other. When the mould was opened the light centre would be found in a number of pieces, or if found whole the same result would be produced if given a light blow. Wherein this example differs from the first is this; the first casting is broken at a part on which there is a tensile stress, and the second, at a part with a crushing stress on it.

Discussion.

The CHAIRMAN remarked that they had had a very excellent paper which must have cost an enormous amount of trouble.

MR. F. J. COOK thought that the paper should be invaluable to those engaged in the light castings trade. He would like to know in a case where they had a casting with ribs on the back, would it be best to cast upwards or down to obtain the best results?

MR. C. HEGGIE greatly appreciated the practical way in which Mr. Fraser had treated the subject and taken advantage of his plentiful opportunities. While there were some points on which he did not agree with the lecturer, there were so many varying conditions that it was most difficult to arrive at any hard-and-fast rule. It seemed that the only safe rule was to anticipate that the result would be different from what was expected or desired. They might build up theories which would wear for a considerable time; but sooner or later (usually sooner) something turned up to upset them. They all agreed that the trouble arose in the cooling, and that the position and size of the runners had a great influence on this. Mr. Heggie recalled a case where a perforated grating was being made with the moulding running all round. It was known from past experience that such castings were down in the drag when cooling, and so the pattern required to be hollow on face. It was

usual to make iron-master patterns from the original white metal patterns, and from the master patterns the actual working patterns were made; thus, if a working pattern required a quarter of an inch camber, the original pattern would, in theory, require three times that amount. Referring to camber, the amount quoted was on 3 ft. lengths, but on the particular pattern he was referring to it was considered that three-sixteenths camber would be necessary each cast; that is, nine-sixteenth on the original; but as a matter of fact, it took three-eighths of an inch on the first cast, this being run off with gates at the side. The original pattern really required one and one-eighth of an inch camber, but for various reasons this was not advisable, and as they felt pretty certain the trouble was caused by the perforated grating cooling quicker than the outside moulding, they decided to make another master pattern and run it with flat gates on the grating. It would have been bad practice to run the casting in the same way, because it was required exceptionally clean, being often ground and polished. This master pattern was satisfactory, and by running the working pattern the same way they found they had nearly the three-eighths of an inch camber required, the master pattern and working pattern only losing three-sixteenths on the two castings. It would thus be seen that the two methods of running gave actually a quarter of an inch difference on three feet. He noticed that in one of the American foundry magazines, Mr. W. J. Keep was reported as saying that it was only necessary to give the foundry a straight pattern, and the moulder would soon give straight castings from it if they discounted his warped ones. They were all more or less admirers of Mr. Keep and his work, but he had no hesitation in saying that this was nonsense, unless the American moulders were far superior to those of this country. Many of them could supply Mr. Keep and his best moulders with many a straight pattern from which they could not make one straight casting in fifty. But even if those straight castings could be made by baring, which was probably what he meant, the practice was a bad one, and a moulder in an up-to-date light castings foundry had very little time for that sort of thing. As regarded altering the position of runners, there were many patterns where that could not be done.

In regard to warps and strains caused by variation in section, Mr. Fraser had not mentioned one factor which must often exert a strong influence, namely, the expansion taking place after solidification. While one part might be cooling slower than another part, still all parts were contracting and cooling down in a fairly regular way. But when they considered the expansion taking place (taking a curve such as Keep's well-known No. 11), they would have, if the irregularities were great enough, one part of the casting reaching its third expansion and still expanding, while another part might be contracting, having passed its three expansions. They would well remember that Keep's No. 11 curves, showing the cooling of an inch square bar, 24 in. long, showed three distinct expansions, the last and greatest taking place from 12½ to 14 minutes after pouring. Professor Turner, in a paper read before the Iron and Steel Institute, on the "Cooling of Cast Iron," showed that in cooling a half-inch square bar the three expansions were quite distinct, but the third was finished 4½ minutes after solidification. There was a difference of 11½ minutes in Keep's and Professor Turner's experiments, although the iron used was grey phosphoric iron with a very similar chemical analysis. With regard to a large plate, three-sixteenths thick, which Mr. Fraser considered as cooling at the edges before the centre, that would depend on where it was run. But if it was run at the sides he would expect the centre to cool first, owing to the metal chilling as it crossed the mould. He had frequently noticed that the runner drew up a plate casting, as, for example, in plates four feet by two feet six and five sixteenths thick, but immediately the runner was knocked off the casting sprang back straight.

The CHAIRMAN agreed that the influence of contraction on gratings was very great indeed.

A hearty vote of thanks was accorded the lecturer, in responding to which Mr. Fraser, replying to Mr. Cook, said they would have less weight if the ribs were cast upwards, because the chill at the top was greater than at the bottom.

Birmingham Foundrymen's Visit.

THE members of the Birmingham Branch of the British Foundrymen's Association, on Saturday, May 16, paid a visit to the furnaces of Messrs. T. & I. Bradley & Sons, Limited, Darlaston. There was a large attendance, including the President, Mr. R. Buchanan; the Vice-President, Mr. R. Mason; the Secretary, Mr.

C. Heggie, and Messrs. F. J. Cook, F. E. Robinson, and Fraser. The visitors were met and conducted over the works by Mr. Bradley and Mr. W. J. Foster, the manager, who is also a member of the Branch. The establishment is known as one of the most up-to-date in the Black Country, and special interest was taken in the turbine plant lately put in by the firm, and which is constructed to develop 20,000 cubic feet ot air against a pressure of 10 lbs. per square inch. This, it may be remarked, is only one-half the capacity eventually to be installed, and for which provision had been made. The turbine and plant generally are so efficient that two ordinary tubular boilers, fed from the waste gases of the furnace, do the whole of the work with considerable energy to spare. The output of the furnace, which has greatly increased during the past few years, is now 700 tons per week. Special attention was called by Mr. Foster to a number of details intended to promote economical working, and an interesting description was also given of the operation of the Foster vacuum and equilibrium system of water control of tuyeres and coolers. In the laboratory, the members were shown the methods adopted for analysis, and a series of records showing that the iron produced had a phosphorus content varying from 0.4 to 1.75. The firm, as Mr. Foster explained, are prepared to quote to specification within those limits.

The visitors were afterwards entertained at tea, and the opportunity was taken by Mr. Buchanan to move a vote of thanks to Messrs. Bradley for their courtesy in exhibiting the works and plant. The firm, he said, had shown courage and enterprise in introducing the Parson turbine for the purpose of providing blast for the furnace, and they were to be congratulated that the installation gave every promise of being a complete success. The iron trade was at the present time passing through a period of acute depression, the duration of which no man could foretell, and it was appalling to think that in the northern part of the kingdom there was being carried on a fratricidal war betwixt employers and employed. Strikes were sometimes necessary, and under some circumstances beneficent, but that could not be truthfully said of the present strike. As trade was conditioned at the present time co-operation and not disruption ought to be the watchword. Mr. Buchanan congratulated Mr. W. J. Foster, blast furnace manager to Messrs. Bradley, on having been elected President of the Staffordshire Iron and Steel Institute. He thought that the British Foundrymen's Association had been distinctly complimented in that two of its members in succession had occupied that honourable position. Mr. Foster was well-known throughout the iron trade as combining in the highest degree practical skill and scientific knowledge as applied to blast furnaces. Having himself melted many hundreds of tons of pig-iron made by Messrs. Bradley, Mr. Buchanan could testify to the excellence of its quality. This was only what one might expect when business enterprise was combined with profound knowledge of blast furnace practice.

Mr. R. Mason seconded, expressing the obligation of the Branch to Mr. Foster for devoting his Saturday afternoon to their benefit, and specially returning from London to meet the party. His explanation added greatly to the interest and instruction of the visit.

The resolution was carried with acclamation, and Mr. Foster briefly acknowledged the compliment.

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SELECTION AND TESTING OF FOUNDRY IRONS.

On Saturday evening, May 9, a meeting of the Birmingham Metallurgical Society was held at the Technical School, Birmingham, when members of the Birmingham Branch of the British Foundrymen's Association attended by invitation to hear a paper from Mr. F. M. Thomas on "The Selection and Testing of Foundry Irons." Mr. Thomas, it may be explained, occupies an important position at the works of Messrs. Belliss & Morcom, Limited, engineers, Birmingham.

Mr. A. H. Hiorns, the President of the Society, occupied the chair, and prefaced the paper by a hearty welcome to the members of the kindred Association. He remarked it was the first time they had been honoured by a visit from the foundrymen, and he hoped it would not be the last. The metallurgists hoped to return the compliment a fortnight later by attending a meeting of the foundrymen, to which they had been invited. Such papers were very helpful in their various occupations. They welcomed Mr. Thomas as a very well-known member of the Metallurgical Society, who had already written several papers and on frequent occasions contributed valuable criticism upon papers

submitted to the Society. Apologies had been received from Mr. R. Buchanan, the Foundrymen's President, and Professor Turner, of the University.

Mr. Thomas, in proceeding to read his paper, also expressed a personal welcome to the foundrymen, whose co-operation was very valuable in elucidating engineering problems. The papers given before the Foundrymen's Association were of a very practical and useful character. They welcomed the Society as jointly engaged with them in promoting the well-being of the great iron and steel industries of the country. With a view to practical utility he had tried to deal with the various subjects in his paper on a commercial basis.

The Paper.

Until a comparatively recent date, the methods adopted in the selection of foundry irons for different classes of work were not such as to commend themselves to scientific minds, and it must be admitted that even at the present time the rule-of-thumb method largely prevailed. Happily for the trade and the prestige of the country, however, this state of things was gradually giving place to better methods, and it was becoming more generally recognised that the best results in foundry practice could only be achieved by the combination of scientific and practical knowledge.

In dealing with the question of the selection of pig-irons for foundry work, there are always commercial as well as practical considerations. Obviously, locality has a great bearing on the matter; consumers in the South of England or the Midlands, for example, could not, except in special circumstances, profitably employ, say, Scotch pig-iron, simply because the heavy freight charges make the cost prohibitive, and this is typically a case where scientific knowledge can be applied with advantage. Instances have occurred of foundrymen, brought up in certain districts and subsequently removed to take charge of a foundry in another part of the country, showing considerable reluctance to use any brands of iron other than those they have been accustomed to, because they are not familiar with the knowledge conveyed by chemical analysis. It is quite true that in certain instances, where the tests required are not too exacting, the pig-iron may be judged by fracture, but it is also well known that pig-irons showing apparently the same fracture to the eye may differ widely in chemical composition. Openness or closeness of grain does not necessarily depend upon any single element, not even on silicon, but on the general composition of the iron, the size of the pigs, methods of casting, and rate of cooling. It follows, therefore, that much of the trouble experienced in foundries working on the "judging by fracture" method could be obviated if greater regard were paid to the chemical and physical properties of the iron as revealed by chemical analysis and mechanical tests.

Classification of the Irons.

The irons most generally used for foundry work may be classified as follows:—All-mine foundry iron, part-mine foundry iron, hematite foundry iron, and for common mixtures cinder pig-iron. All these are made with hot blast, but for certain purposes it is desirable to use cold blast or special refined irons. Hematite iron contains about the same proportion of sulphur but much less phosphorus than other brands of other foundry iron; it is soft and tough, and is used in mixtures to impart strength and prevent contraction. Swedish and charcoal pig-irons are the purest and strongest made. They are produced in very small furnaces using cold blast. Special qualities of Swedish charcoal, cold blast, grey foundry pig-irons have a tensile strength of 16 to 18 tons per square inch, and a transverse strength of 42 to 44 cwts. on a 2 in. by 1 in. bar, 3 ft. between supports, while a typical analysis would be:—Graphite carbon, 2.8 per cent.; combined carbon, 0.5 per cent.; silicon, 2.0 per cent.; sulphur, 0.03 per cent.; phosphorus, 0.08 per cent.; manganese, 0.6 per cent. Refined pig-irons are especially useful in the production of locomotive and marine engine cylinders, or for other castings requiring a hard, close grain of great density, capable of machining up to a highly finished surface and possessing good wear resisting properties.

Irons from various Districts.

In certain districts iron is still made with perfectly cold blast, and is the best iron for chilled and grain rolls, cylinders, hydraulic presses, and other purposes where great strength and closeness of grain or chilling properties are required. Cold blast pig-iron is chemically purer than hot blast, and apart from the purity of the ores used, contains much less silicon than the corresponding number of hot blast iron. Moreover, notwithstanding the lower content of silicon, the graphite carbon chiefly exists in the finely

divided state. At the comparatively low temperature of a furnace working with cold blast a much less quantity of impurities is reduced and taken up by the iron, and this, combined with the close molecular structure, accounts for the superior strength of cold blast pig-irons.

The quality of pig-iron must necessarily depend upon:—(1) The class of materials (ore, flux, and fuel) used in its manufacture; (2) the capacity of the furnace, temperature of the blast, and general conditions of working. There are still certain definite characteristics associated with pig-irons produced in different districts, notwithstanding that to some extent, in such places as Scotland, Derbyshire, and Staffordshire, local ores have become almost exhausted, and ironstones from other districts are employed. Northamptonshire, Derbyshire, and Cleveland pig-irons contain more phosphorus than do those from other districts, whilst Scotch pig-irons and those from Lincolnshire, and some parts of Staffordshire, are notable for their high content of manganese. It must not be assumed, however, that all pig-irons produced in the Cleveland district are of common quality high in phosphorus; some makers use a mixture containing upwards of 30 per cent. hematite ore, to make a specially rich soft foundry iron, capable of taking up a large quantity of scrap when remelted in the cupola, and these irons are equal to Scotch brands for foundry work.

Effects of Individual Elements.

Each element has a definite influence on the physical characteristics of the iron, but the direct effect of any single element may be considerably modified by the presence in greater or less proportion of other metalloids, and, therefore, care should be taken not to arrive at erroneous conclusions by too strict reliance on what may be termed the broad or general effect of any individual constituent of the iron. The total content of carbon in most pig-irons is fairly uniform, but the effect exercised by carbon depends upon the form in which it exists, whether as combined or graphite, and the influence of the other elements on the iron is largely proportionate to their influence on the carbon. Elements which tend to combine the carbon harden the iron, whilst those which throw out the carbon as graphite act as softeners. Irons containing a low content of carbon require more silicon to produce greyness than is the case if the total content of carbon is high. Graphite carbon both softens and weakens the iron, whilst combined carbon hardens, increases the shrinkage, decreases the deflection, and raises the tensile strength. Broadly, the effects of the various metalloids in cast iron may be defined as follows:—Combined carbon hardens and strengthens, graphite carbon softens and toughens, silicon softens and promotes fluidity, sulphur hardens and closes the grain, but if in excess causes blow holes, weakness, and shrinkage, phosphorus increases the fluidity, but in excess causes weakness and brittleness, and manganese hardens and increases the contraction and tends to render sulphur innocuous. Titanium is sometimes present in proportions ranging from 0.05 to 0.4 per cent., a quantity which is not injurious; on the contrary, it acts as a strengthener, and is useful in the production of chilled castings.

Silicon.

Silicon and carbon are the two elements which chiefly affect the grade of the iron; this is because they have a distinct bearing upon each other. Silicon ensures softness by preventing the carbon from combining with the iron as soluble carbon, but if the content of silicon exceeds the amount necessary for this purpose, then the silicon itself actually becomes a hardening agent (say over 4 per cent.). The softening influence of silicon is also considerably modified by manganese and sulphur, due to these latter elements tending to combine the carbon, but in the ordinary way it is found that the softening effect of silicon is greater than the hardening effect of other elements in like quantity. Silicon increases fluidity, lowers shrinkage, and, like aluminium, tends to keep occluded gases in the soluble form until the metal has solidified, thereby preventing blow holes.

Sulphur.

Sulphur increases during the melting of iron, due to the concentration, and to the fact that the fuel (unless charcoal be used) contributes more sulphur to that already present. Hence, in making or remelting a good class of iron, pure fuel is necessary. Generally speaking, more sulphur is found in pig-iron first tapped from a blast furnace, due to its contact with the bed of incandescent coke, than in that which comes down later, hence the advantage of a receiver or large ladle to ensure proper mixing. The direct influence of sulphur is considerably modified by the presence of manganese, although both are hardening agents. Sulphur, if

present in large proportion, renders the iron weak or rotten, but manganese, having a greater affinity than iron for sulphur, combines with the sulphur as manganese-sulphide, thereby preventing the disastrous effects which would be produced by the formation of iron-sulphide. For the ordinary run of iron castings sulphur may almost be disregarded, since, generally speaking, the content of this element in ordinary pig-iron is usually kept sufficiently low to prevent any trouble.

Phosphorus.

Phosphorus, of all the elements, is the least under control in the blast furnace, and the most difficult to get rid of; consequently practically all the phosphorus present in the ores goes into the pig-iron. The most efficient flux for eliminating phosphorus is fluorspar, but even under the best conditions, owing to the affinity of iron for phosphorus and the difficulty experienced in oxidising the latter element, the only safe way of keeping it out of pig-iron is to use ores free from phosphorus. Phosphorus does not appear to have any direct hardening effect, but when present in appreciable quantity it tends to displace the carbon, reducing the total carbon content and thereby promoting hardness. In excess quantity it causes weakness and brittleness, and must be rigidly excluded for malleable ironwork or castings where great strength and toughness are required. Its principal beneficial effect is that it makes iron fluid, therefore, for intricate light or ornamental castings, where no machining is required and a sharp, clear impression is wanted, phosphorus up to 1.5 or 1.6 per cent. is a distinct advantage to the work. Iron of this grade should not be poured at too high a temperature.

Manganese.

In producing pig-iron the manganese can be oxidised and got rid of by working the furnace with a cool blast and a basic slag. For economic reasons the slag must be rendered basic by a generous use of flux, otherwise the loss of iron in eliminating excessive manganese would be considerable. Under proper working conditions a fair proportion of manganese is always got rid of, but in certain cases it is, of course, desirable to retain the manganese in the iron. Manganese, besides eliminating and counteracting the deleterious effects of sulphur, also acts as a protecting agent to the silicon, which in the absence of manganese would be largely oxidised during melting; this should be borne in mind when arranging mixtures where certain definite results are required.

Drilling for Chemical Analysis.

Each consignment of pig-iron received by the consumer should be analysed. In some cases it may not be necessary to ascertain the percentages of all the constituents, but, generally speaking, it is far safer to have a complete analysis taken. To ensure getting a thoroughly representative assay, four pigs should be taken haphazard from each 10-ton lot delivered; these should be broken in halves and one-half of each pig drilled; the drillings should be thoroughly mixed before taking out the portion for analysis, and the remainder of the drillings retained for reference in case of dispute. The chemical composition, particularly in regard to sulphur, may vary in different parts of an individual pig, and for this reason it is necessary to drill in such a manner, as will ensure a result representative of the whole.

At some works drillings are taken from the side of the pigs, others drill the pig through from top to bottom, while a third method is to drill longitudinally from the fractured surface. All these methods are satisfactory, although by the first two methods a more accurate estimation would probably be obtained in regard to the combined carbon, seeing that these two would each contain a portion of the outer zone which is usually the hardest part of the iron. If the drillings are taken by this method, the pigs should be thoroughly brushed with a wire brush to remove all traces of sand, or, better still, the drillings to the depth of $\frac{1}{8}$ in. should be discarded, as sand in the drillings would affect the silicon content. Herein lies one of the weak points of chemical analysis as a guide to the characteristics of iron. The basis of chemical analysis is the oxidisation of the various constituents, and, therefore, if sand (oxide of silicon) be present the estimation of silicon is correspondingly increased. The same remarks apply to drillings taken from segregated or dirty portions of iron castings, in which metallic oxides are present, and for this reason chemical analysis, although a valuable aid in foundry work, will not explain all the difficulties experienced in foundry practice. Consequently, foundrymen are frequently at a loss to explain why castings are defective when the analysis shows a comparatively satisfactory iron.

Causes of Defects in Castings.

A very slight difference in the chemical composition of iron may alter its physical properties and mechanical tests out of all proportion to what might have been expected from the chemical analysis. Good Swedish pig-iron, with a tensile strength of 14 tons per square inch, may easily be spoilt in re-melting, so as to give tests equal only to common iron. Segregation, blow-holes, and draw may occur in castings made from very pure iron, and the iron be blamed when the fault is due either to the conditions of melting, the temperature of pouring, the design of the casting itself, or, perhaps, to all three causes. The greyer the iron, that is, the higher the content of graphite carbon and silicon, the less is the tendency to segregation and draw; the harder the iron (especially if hardness is due to an increased quantity of manganese and sulphur) the greater the tendency both to drawing and segregation.

The chemical reactions taking place in molten iron vary at different temperatures, different eutectics being formed, and the hotter the iron beyond the necessary temperature for fluidity the greater is the liability for the metalloids to segregate during cooling after the castings are poured. The softer and greyer the iron the hotter should be the casting temperature; for very hard, strong castings the temperature should be sufficiently high for proper pouring and feeding to secure density of structure. The volume increases with the temperature, and the contraction varies with the number of degrees passed during solidification and cooling; therefore, if the metal is poured hotter than necessary, the risks of drawing and segregation are proportionately increased. Moreover, what applies to one grade of iron does not apply to others; a different form of crystallisation and rearrangement of particles takes place in a soft iron, as compared with a hard one, as is readily seen in micro-photographs. The chemical reactions in an iron containing high silicon and low manganese, for example, are quite different from those occurring where the metal contains less silicon with more manganese and sulphur, and much greater risks are incurred in overheating a pure iron (that is, one containing a high percentage of iron and low total content of the metalloids), such as is used, say, for making engine cylinders, than is the case with an ordinary siliceous grey pig-iron.

In selecting pig-irons for foundry mixtures where important castings are concerned, the information conveyed by chemical analysis should always be supplemented with mechanical tests, and, where possible, with microscopic examination. Each brand of pig-iron before being put into the mixture should be separately tested for tensile and other tests, similar tests being also made on bars cast from the mixture. Unless this is done, doubts may exist as to which iron is causing trouble, if any should arise.

Mechanical Tests.

The simple operation of breaking a pig and examining the fracture gives some idea of the quality of the iron. If hard, the fractured surfaces have sharp edges; if tough, the surface is uneven, showing what the foundryman calls "pull." The effort required to break the pigs depends upon their length and section, and also upon the rate of cooling, and is not, therefore, a safe indication of the mechanical properties of the iron.

The principal mechanical and physical tests applied to cast iron are:—Tensile strength, transverse or bending (noting deflection), hardness, contraction or shrinkage, and crushing or compression. Sometimes, but very rarely, torsion tests are taken, but these are hardly worth the trouble, as toughness is equally well indicated in other ways, and obviously cast iron is a metal quite unsuitable for parts subject to tortional stresses.

For ordinary engine castings, tensile and transverse tests are usually considered sufficient, but for constructional work, such as columns, crushing tests should also be taken. It would greatly facilitate matters if test bars were standardised. At present, not only do the methods of making the test bars vary, but there is no uniformity in the sizes of the bars used.

Tensile test bars should be cast 12 in. long by 1 in. diameter, turned in the centre for a distance of 2 in. to 0.798 in. diameter (equals $\frac{1}{2}$ square inch area), the ends being machined to suit the grips of the testing machine.

Transverse test bars should be cast 14 in. long by $1\frac{1}{4}$ in. square, planed all over to 1 in. square, and placed on supports 12 in. apart; sometimes the bars are cast 2 in. by 1 in. for 3-ft. centres.

Hardness test bars should be 12 in. long by $1\frac{1}{2}$ in. diameter, and one side planed flat for a length of about 6 in. The bars are then drilled through with a $\frac{5}{16}$ in. diameter drill, to remove any hard spot which might injure the drill point, and so give an unreliable record. Two standard drills (preferably $\frac{3}{4}$-in.) are then run through to a depth of 1 in.,

with a known weight (equal to 600 lbs.), acting on the point of the drills. A diagram is taken on squared paper, showing the number of revolutions required to drill 1 in. deep. If the metal is homogeneous throughout, a diagonal line is described on the chart; if the drill drops into a soft place the line takes a vertical direction, whilst if a hard spot is encountered, the line runs horizontally until the drill has penetrated the hard place. The number of revolutions required to penetrate 1 in. deep indicates the hardness; the same drills should be used each time, and the points ground after each operation to the same angle. Two holes are drilled with each drill and the mean taken as the result.

A simple means of ascertaining the amount of contraction is that known as Keep's test. By this means two bars of small section are cast between the ends of an iron yoke 12 in. in the gap, the amount of contraction being measured by inserting a graduated wedge-shaped scale between the ends of the cast bars and the yoke, readings on the scale giving tenths of an inch per foot.

Crushing tests are rather difficult to take, and in the majority of cases are considered unnecessary, seeing that as a general rule cast iron which has a good tensile and transverse strength shows up well under compression. The simplest method of testing for compression is to fix the test piece between the base of stirrups attached to an ordinary tensile testing machine, and then operate the machine as for tensile tests. The form of specimen is of the highest importance, because if the length is considerable as compared with the diameter, the fracture will be brought about by bending instead of crushing. The mode of fracture is by shearing at an angle with the direction of pressure; this angle varies somewhat, but should be in the neighbourhood of 35 degrees. If the specimen is too short, this natural angle of shear will be interfered with, and the rupture stress raised; therefore, to obtain a satisfactory test, the length should be from two to three times the diameter, larger diameters allowing the longer length.

Discussion on the Paper.

The CHAIRMAN remarked that the paper was the result of close observation, during long experience in connection with cast iron. Its value had been enhanced by its clear and able delivery. It appeared to him that Mr. Thomas put practice before theory as a matter of importance, but they were both necessary. A little theory was better than none, and he would rather have 5s. a week at 70 years of age than nothing at all. (Laughter and applause.) With regard to the greyness of the iron, that was due in many cases to the length of time the iron was exposed to a sufficiently high temperature, and to the rate of cooling. When it had passed a certain temperature, the cooling made no difference to the graphite. As to the statement respecting cinder pig-iron, he was under the impression that cinder pig was never made entirely from tap cinder, but generally mixed with a certain amount of mine as well. As to the use of nickel in cast iron, nobody knew exactly what was the effect of nickel. No doubt it had a very important influence upon cast iron, and further experiments were being made to test this. The reader of the paper was mistaken in saying that nickel melted at 1,550 degrees Centigrade. Ordinary commercial nickel would melt at 1,400 degrees Centigrade. It was correct that silicon had the effect of producing grey iron and therefore softening its character, but that depended upon keeping the metal at a certain high temperature for a sufficient length of time. For instance, if they had 2 per cent. of silicon in cast iron and cooled quickly, they would not get grey iron. He had seen such iron cooled quickly which became absolutely white, and where the carbon was graphitic in form, it was purely a question of time and temperature. The same principle would apply to iron having a white centre which was entirely due to the fact that the greater part had been cooled at a different rate than the other. On the question of analysis, as compared with fracture, he did not think it was fair of anybody to complain of chemical analysis if they claimed for it more than the chemist himself claimed. The chemist merely reported that there was so much combined carbon, so much graphite, and so on. But he did not pretend to tell what condition the graphite was in. It might appear in the combined form or in the segregated form, which was very hard, or in the form of pearlite, where it would be much less hard. They needed the microscope rather than the chemist to tell them the condition of the various constituents. Generally, it might be said that ironfounding was a highly scientific industry. They met with so many difficulties which showed the enormous importance of the scientific or theoretical side. Keep's test was only capable of deal-

ing with small quantities, and the question is: Does this indicate what occurs in a large piece?

Mr. Parker, who described himself as a visitor, wished to correct the statement that Swedish iron was all cold-blast iron. That was not correct, inasmuch as only three or four brands were cold-blast. They were all charcoal irons, and that accounted for their great purity. Very pure cokes were also used. He held that North Staffordshire irons should be classed differently to those from South Staffordshire, which were rather parallel to Northampton brands. One of the objections put forward to working from specifications was that most ironmakers were either ignorant or careless in their manufacture, but that was no reason for rejecting altogether the system of specification. As to the use of nickel, he had used it extensively in the form of ferro-nickel by charging it into the furnace. He thought that was better than putting it into the ladle. The subject was being very widely studied, although very little had been published. With regard to drillings for analysis, if those taken from the first one-eighth inch be discarded, the drillings might as well be taken from the fractured surface. Many foundry foremen objected to the surface being taken off test bars, but the skin could only be important in cases where the chilling effect would have something to do with the test. Taking the ordinary run of foundry irons, it would not matter whether the surface were planed or not. He would like to know how much special pig-iron was charged in the mixture which was said to be so strong for cylinders? Did Mr. Thomas find it necessary to charge up to 50 per cent. of special pig-iron in a mixture, or could he work with less, to get 12 or 13 tons tensile strength? In America they got some very good tests, and he noticed that a Watertown firm had averaged 16 tons, and had been able to run up to 18 tons tensile strength. That would show they were very successful in the production of test pieces. In this country British firms were obliged to keep up to the arsenal test, or they never got another order.

Mr. G. Hailstone considered the information with regard to the formation of graphite should have been more precise. With regard to drilling, he found the best practice was to drill through the centre. The speaker referred to the process of photographic sulphur printing by Mr. Stead, described at a recent meeting in Dudley, by which it was possible to show the amount of sulphur present. He had made experiments with this process which had worked very successfully, and could practically be done by anybody. In reference to fracture, could Mr. Thomas actualy define the fracture of No. 3 foundry iron? So far as nickel was concerned, he found that it had a marvellous effect on the chilling properties of cast iron, but his experiments were not sufficiently advanced to enable him to make a definite statement as to its precise effect.

Mr. Parker said that his system of drilling was the better one. In the bottom part of the pig there was three times as much sulphur as at the top.

Mr. W. J. Foster said he had been very interested in the paper, which was very valuable from a commercial point of view. Something was said about grey iron containing only 0.84 per cent. of silicon. He had made iron containing only 0.48 per cent. of silicon, and apparently it contained as much graphite, and in as large flakes as iron containing 3.5 to 4 per cent. The knowledge of graphite and its segregation was very valuable indeed to anyone who had anything to do with the purchase of pig-iron. For instance, with the general knowledge of the physical properties of iron it was possible to tell approximately the analysis of the iron as it was leaving the furnace. When they saw the iron tapped they could say that it contained so much silicon, phosphorus, manganese, and total carbon. A great deal of importance attached to the carbon contents. There were two different forms of carbon, and it was very easy to discover at a glance the difference in the crystalline form, which indicated the general composition of the pig. With regard to blow holes in castings, which were said to be due to sulphur, he had on many occasions tried to point out that that was not the true cause. He had known contraction holes from low silicon contents, but had never known blow holes due to sulphur.

Mr. A. H. Hiorns remarked that blow holes could arise with a small quantity of sulphur, and if they introduced a larger quantity they would get the iron like a sponge.

Mr. C. Heggie expressed the thanks of the foundrymen for the invitation to the meeting, though he regretted the absence of some leading members. With regard to Keep's tests, he imagined that Keep did not claim to give by that test the actual contraction. It was really only a relative test. Probably it would not give the actual contraction, because of the

introduction of the chill which was caused by the yoke.

Mr. Thomas, in reply, said he quite agreed with what Mr. Hiorns said about the separation of graphite at different temperatures. Professor Turner had shown that the separation took place at certain temperatures. Cinder pig could be made with all cinder, or mixed with part mine, but if much of the latter were used it would no longer be cinder pig. Certain difficulties had been met with in the melting of nickel. In fact, it would not melt in the ladle, and the temperature capable of melting iron would not melt commercial nickel. That was why nickel, aluminium, and titanium were introduced as special alloys, and it was necessary to vigorously agitate the ladle to insure thorough diffusion. The value of Keep's contraction test lay in the fact that if the shrinkage was measured when the iron was giving satisfactory results, it was only necessary to continue this shrinkage each day, and the iron would be of uniform quality. A measure of shrinkage would not, however, indicate an exact amount of silicon. A variation of the other elements would alter the percentage of silicon necessary to produce certain shrinkages. He agreed with Mr. Foster that it was possible to get iron giving a grey fracture with less than 1 per cent. of silicon, and they could have hard iron with as much as 1 per cent. He did not mean to convey that Swedish irons were all cold-blast. The particular brand he referred to was a cold-blast, and in regard to Staffordshire iron, while he gave a typical example, he was well aware that there was a wide variation in chemical analysis. The question of drilling was admittedly a debatable point, and some chemists naturally thought their own methods were the best. His own advocacy of planing test bars was based on the removal of any possibility of quibbling. Anybody who had to do with inspecting, and particularly those representing Government offices, such as the British Admiralty, knew how very particular inspectors were to ensure that the tests were genuine. One advantage of planing was that it removed any argument as to whether strength was derived from a chilled outer skin or the inherent strength of the metal itself. The British Admiralty test was so easy that almost any reasonably good foundry iron would give it. The cylinder mixture he had referred to consisted of refined iron with a proportion of scrap from a previous melt, and some good high-class No. 3 foundry iron, but the proportions must be left to the discretion of the foundry manager concerned, because cylinders hard enough for one firm would not be hard enough for another. It was not uncommon to get tensile tests from 15 to 17 tons per square inch with this mixture. With regard to Mr. Hailstone's request for a definition of the fracture of what was called No. 3 iron, his answer must be that there was no recognised standard. He had frequently appealed for some standardisation. At present the chemical analysis varied within very wide limits. With regard to sulphur, blast furnace managers took particular care not to admit it in injurious quantities. As a matter of fact, hematite irons often contained more sulphur than foundry irons, and, as a rule, the sulphur in foundry irons was not sufficient to do any harm. Certain objections had been urged against the use of machine cast pig-iron on the ground of chill, but he did not think that was a serious matter, because in re-melting, the iron could be mixed to get the desired results. There were obvious advantages in using machine-cast pigs, such as freedom from sand and less fuel and flux consumption.

A vote of thanks was accorded the lecturer on the proposition of the Chairman, seconded by Mr. Heggie.

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PROPELLERS.

By W. Ashcroft.

In a previous issue was given a detailed account of the making of the pattern-work for a 12 ft. propeller with 12 ft. pitch; in the present article will be treated the foundry work in connection with the same. When the moulder is told to prepare for a 12 ft. propeller, he has the plate placed in a position handy for the labourers in bringing loam and bricks, within reach of both overhead travelling crane and hand crane, if possible, also giving due regard to the drying of the mould. Some firms only occasionally make propellers, and often have not stove room for them. In such cases they are often made in a pit, which is generally used for condensers or bedplates, the idea being that a cover can be placed over with the mould enclosed and made into a temporary stove. But other works which make a speciality of propellers have gauged lines let into the ground, running into special drying stoves, and the propeller plates have flanged wheels attached. There are other processes, but this one is preferable, as the mould can

be easily run into the stove without jolting, which might seriously interfere with the pitch. Now suppose the tackle is already made, which I will try to explain in the building process. Fig. 1 shows four grades in the construction of the mould. Each of these four are termed "wings," and hereafter will be named A, B, C, and D. The outside view of Fig. 1 is the main plate upon which the moulder commences his work. Looking at Fig 2, which represents a sectional elevation of Fig. 1, it will be seen that

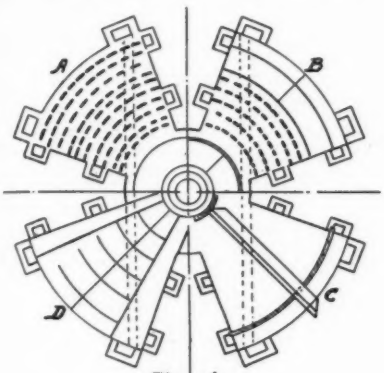

Fig. 1.

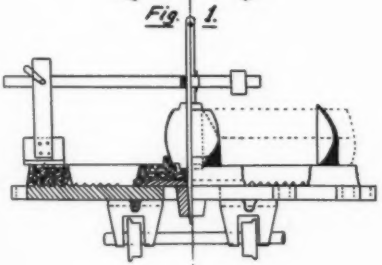
Fig. 2

a hole is cast in the centre of the plate to allow for another plate, into which a centre pin revolves; this plate is termed "the centre plate." It has a tapered hole into which a machined pin or spindle is made to fit exactly. Fastened to this pin, at right angles, by wedges, as shown in Fig. 2, or by a set bolt, is a wrought iron rectangular bar, termed a "tail." A commencement can now be made in the sweeping, which is done first by the revolution of a board set vertically to the spindle and clamped to the tail at a certain distance from the centre of rotation. The first board or sweep to be used will be the "cup board," which sweeps out part of the boss, a bearance for the centre core, and also a bearance for the inside angles. This first sweep, which the moulders term "the cup," is stiffened by the application of a small fire, after which a loam pattern is swept for the boss, having a print on top to suit the core. The short tail which has been used in the sweeping of the boss can now be replaced by a much longer one, sufficiently long to take the board which sweeps the bearance for the outside angle, which must be on the same level as the bearance for the inside angle, as shown on the left side of Fig 2. Reverting to Fig. 1, wing A shows a part plan of the plate, which must be about a foot larger than the diameter of the propeller to be made. To be noticed also are a series of metal prods cast with the plate; these are to give a better hold to the loam. Wing B illus-

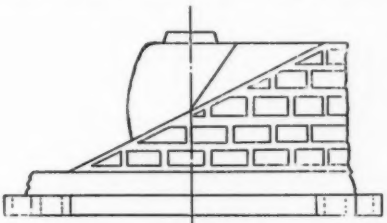
Fig. 3.

trates both bearances having been swept, and, as was mentioned in the former article, a mark is made in the outer bearance at which the outside angle is to stand; that is, 12 ft. diameter. After standing for an hour or two the bearances are ready for the patternmaker to set the angles. First, he will see if the bearances are correct, and then mark the centres on them. In the present instance the centre line passes through the centre of the blade, so that the patternmaker will bisect the outer bearance on one of the wings and divide the whole into four from the centre thus made. Now, as the centres on the angles were projected down to the base, they are required to be placed on the corresponding centres on the bearances. The moulder will commence to build up each wing to the shape of the angles which have been set. The process of building up is done with firebricks and loam, the bricks being placed clear of a strickle, which is worked over the angles, illustrated by Fig. 3. The workman will need to be very careful in getting the correct sweep. The angles have a series

of marks on the edge, so that when sweeping with the strickle at any part of the bed it must always be running into the centre of the boss. For instance, there are twelve marks on each angle; supposing the strickle to be placed at the first mark on the outside angle, it must also be placed on the first mark on the inside angle, so that wherever the strickle may be placed on the outside angle it must be on the corresponding place on the inside angle.

After having built each wing and made preparation for the top covers by levelling the loam at the top and bottom of the blades, as shown by Fig. 3, the whole will be required to be stoved till dry. When the mould is dried to the satisfaction of the moulder, it is the duty of the patternmaker to mark off the shape of the blades (this is done by scribing a series of radial lines on which the tem-

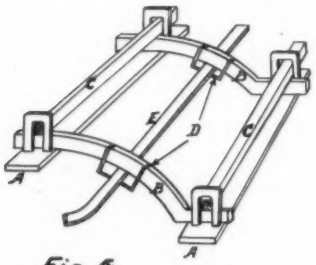

Fig. 4.

plates for the thickness of the blades are to stand), also to mark the centres of blades, as shown on wing D, Fig. 1. Turning to the original drawing, the widths of the blades will be found; these are to be marked at equal distances on each side of the centres already marked on the mould, and a nail or sprig knocked into the loam at these distances. The services of a blacksmith will now be required to bend two pieces of iron ($\frac{3}{4}$ square) touching these sprigs, and meeting at the top of the blade, the shape shown by the inside of these irons to be the true shape of the blades. One set of irons will do for the four blades. These irons are fastened on the bed and the thickness pieces placed at their proper positions, in readiness for the moulder to commence to form a temporary pattern of each blade. He will do this by filling the inside of the irons with black sand and strickling over the thickness pieces with a fillet worked up against the boss. When one is finished the thickness pieces and irons can be transferred to the next wing, and so on, until all four blades are finished, thus completing a temporary pattern of a propeller. Covering is now commenced by giving the whole surface a generous sprinkling of parting sand, to ensure easy separation at the joint when required. Fig. 4 represents the formation of the plates and bars for binding together the tops for each wing. First, plates A are clay-washed and bedded into loam, which is placed on the bearance at the top and bottom of each blade. Next, cast iron bars B are placed against the inside of the lifting irons, which are cast in plates A; these are kept immovable with bars C, being wedged down upon bars B. A number of pieces are then bent over bars B, hanging about three-quarters of an inch above the pattern of the blade; these are to support a series of rectangular iron bars, one of which is shown on Fig. 4 by E. Loam is spread over the surface between the plates A, and

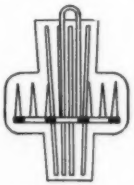

Fig. 5.

the bars E are bent at one end to follow the fillet against the boss and are "clay washed," to help the loam to adhere to them. Then they are bedded into the covering of loam till they rest on the iron hooks D, to be kept in position with pieces of metal packing wedged between them and bars B. Another covering of loam is placed between plates A, and a parting or joint made for a covering for the top of the boss. When making this joint the largest size of the core must be taken into consideration, sufficient clearance being allowed to ensure the core being placed in position without catching the mould. When each wing has been covered in this way the moulder will next proceed to cover the top of the boss. First he will give the joint a good sprinkling of parting sand, and then cover up with loam, sufficient to cover the print swept on the boss. A clay-washed plate is then bedded into the loam; this top plate must have a round hole cast in the centre to let the air off the centre core,

and also provision must be made for the metal passing into the mould and the air passing out. The mould can now be placed in the stove to dry, and, in the meantime, the moulder can commence with the core, so as to have it in readiness to blacken when the mould has been blackened. To commence the core, he will sweep a core box on a plate with the core box board fastened to a tail on a centre pin, similar to the method of sweeping the cup. When this core box is swept out the tail is taken off the pin to allow a grate to be placed in the core box. The tail is then replaced and the top core board fastened to it, making a core similar to Fig. 5. The centre of this core is filled with ashes to allow the air to escape when casting. After having broken away part of the core box, leaving only sufficient for a support, the core will need to be dried. When the propeller mould is satisfactorily dried it can be taken out of the stove and preparation made to lift the covers, the first of which will be the covering on the boss, so that the temporary pattern for the boss can be broken out to free the covers on each wing. The moulder will, of necessity, exercise great care in the lifting of the wing covers, marks being made all round the joint so that they can be placed in their correct position again without any doubt. The tops having been separated, the sand pattern is scraped off the bed and all parts of the mould which the metal comes in contact with can be blacked over with a mixture of blacking, plumbago, gum, and water, so as to give the metal a good, smooth skin, after which the whole will require to be stoved preparatory to casting. A coating of blacking is put on the core, and this also stoved. Meanwhile, the moulder can prepare a runner sufficiently large to act for a head to take the dirty metal. When mould, core, and runner are completely dry, the moulder can prepare to cast. First, all dust is taken out of the mould; the wing covers are then placed in their correct places and clamped to the main plate, and the centre core rested into the recess swept out for it. The cover for the boss is next placed and fastened down in such a manner as to resist the lifting of the metal when casting; this can be done by placing a couple of long metal bars on the top plate and clamping them to the main plate at each end, allowance being made for the runner, which is laid on top so that the metal will find its way into the mould. When all covers are carefully fastened to the main plate, and the joints covered with loam to stop the metal if it should find a way out of the mould, the metal can be poured in and afterwards fed as long as it remains liquid.

The foregoing articles have dealt with the simplest style of propeller; that is, a straight propeller (one having the centre line of the blade perpendicular to the shaft). Those not familiar with propeller work will more easily follow the principle of the making of a simple one, where the angles are set on level bearances, than an "angle back" propeller, where the bearances are not level.

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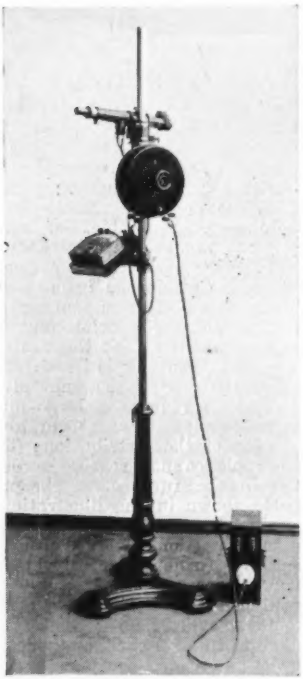
OPTICAL PYROMETERS FOR TEMPERATURES ABOVE 600 DEGREES C.

Optical pyrometers are employed for the determination of high temperatures in those cases where thermo-electrical pyrometers are not suitable. For instance, if :—(1) The temperature lies above the range of the thermo-electrical pyrometer; (2) moving masses in the furnace render the introduction of a measuring apparatus impossible; (3) deleterious gases are present which attack the protecting tube or the thermo-couple itself; (4) the heat of the furnace is so unevenly distributed as to require a large number of thermo-couples in order to give a correct idea of the distribution; (5) the thermo-couple cannot reach the desired position in the furnace. The optical pyrometer shown in the illustration has been designed to meet all such cases, and claims to be particularly suitable for use in smelting furnaces, porcelain kilns, and glass furnaces, gas-retorts, etc.

The intensity of the light rays emanating from a so-called "hot-body" (that is, any almost totally enclosed space), is directly proportional to its temperature. The ratio has been scientifically and accurately determined and is used as the basis of the principle of the optical pyrometer. By means of this apparatus the intensities of the light rays of unit areas are compared, that is, the light from two glowing bodies; the temperature of one is variable and known, that of the other has to be determined. Their temperatures are equal if the specific intensity of light is the same.

The comparison is made in the following manner :—The telescope of the optical pyrometer is directed on the "hot-body" (*e.g.*, the sight-hole of a furnace), when the field of vision appears brightly

illuminated. The filament of an incandescent lamp passes across the line of vision inside the telescope, and so long as no current flows through it, this filament appears as a dark line on the bright background. The lamp is now switched into the circuit of a small accumulator, and the current is regulated by means of a rheostat until the incandescent filament becomes invisible on the bright background. The temperature of the filament is then the same as that of the furnace. The ratio of the temperament



OPTICAL PYROMETER, SET UP READY FOR USE

of the filament to the current is accurately determined by the Government Physical Laboratory at Charlottenburg, and the deflection of the milli-ampere-meter in the lamp circuit corresponds to the temperature of the furnace when its incandescence and that of the filament are equal.

Should the temperature of the furnace be a higher one than the filament could stand without damage, a light absorption device is placed in front of the telescope. This consists of a combination of prisms having a degree of absorption which is also determined by the Government Physical Laboratory. As the colour intensity might then render difficult the adjustment to equal incandescence, the comparison of the intensity of the light rays is confined entirely to the red rays by red screens placed in front of the eye-piece. By means of this arrangement in connection with the absorption device, the upward range of the optical pyrometer is practically unlimited.

The parts of the optical pyrometer consist of a telescope with electric lamp, rheostat, and milli-ampere-meter; these, combined with a stand, make up a handy and portable apparatus. The portable accumulator, which gives 4 volts, is connected up by means of a plug.

The chief advantages claimed for this optical pyrometer are as follows:—The measuring apparatus is not subjected to the temperature to be measured, and therefore there is practically no deterioration; the apparatus is made in a convenient form; the method of using it is simple; the milli-ampere-meter has a clear open scale, and the readings are very accurate, as the light intensity increases rapidly with the temperature, and is thus an excellent criterion of the latter.

For the above particulars we are indebted to the makers—Messrs. Siemens Brothers & Company, Limited, Queen Anne's Chambers, Broadway, Westminster, S.W.

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MESSRS. J. JOPCH and A. MULLER, mechanical engineers, White Lion Street, E.C., have dissolved partnership.

THE PARKER FOUNDRY COMPANY, LIMITED, of the Tropenas Steel Works, Derby, who recently erected a new steel foundry at Little Chester, Derby, have just completed an important extension, doubling the area. Mr. H. W. Surtees, has also turned his company into a limited liability concern, and has now associated with himself as joint managing director Mr. Thomas M'Lean. There has been installed a plant on the "Tropenas" system, and the works are specially laid out for the production of high-grade steel castings suited to the varying requirements of engineers. Mr. Thos. M'Lean has been for the past 17 years with Messrs. Edgar Allen & Company, Limited, of Sheffield. Mr. W. R. Thompson becomes a director, and will act as secretary of the company.

The "Foundry Trade Journal" Bookshelf.

It is proposed, on this page, to deal with various books likely to prove of interest and instruction to any branch of the Foundry workers, and not only new books appearing will be reviewed, but any that are now on the shelves and are obtainable from the publishers.

An endeavour will be made to present the salient features of these books to our readers, so that those desirous of advancement may learn to some extent what publications will best meet their requirements.—THE EDITOR.

LECTURES ON IRON-FOUNDING.

By Thomas Turner, M.Sc., A.R.S.M., F.I.C.

In presenting these lectures to the public in book form Professor Turner made permanent what had already been thoroughly appreciated by those who were fortunate enough to hear the Professor of Metallurgy in the Birmingham University when he delivered the lectures. As he explains, the book may lack some of the advantages of practical illustration at the lecture table, but, nevertheless, it is sufficiently useful and practical to justify the prominent place in foundry literature that has been accorded it. To many foundry students the book is already familiar; to others some information on the matter will be useful. Since the audience for which the lectures were prepared was essentially a practical one, they are encumbered with neither detailed descriptions of practical manipulation, nor tedious theoretical explanations. The first lecture treats briefly with the varieties of iron and steel and their carbon contents, following with the history and applications of cast iron.

The author graphically distinguishes between the different ores used in the manufacture of iron, and enumerates the properties of each and the treatment; he also describes the general arrangement of blast furnace plants.

The second lecture describes in detail the blast furnace, its construction, and the manner of working it. The products of the furnace, the grading of pig-iron, and the connection between grading and chemical composition are in turn considered.

The constituents of cast iron and the influences they exert on the metal are dealt with in another lecture. "Cast iron," says the author, "is not an element, nor is it a compound, nor an alloy. It is a complex aggregation which includes elements and compounds, and supplies examples both of chemical combination and of mechanical admixture." He then proceeds to consider in detail the influence and state of combination of each of the elements which are ordinarily present in cast iron, commencing with carbon and its forms of occurrence. In treating with silicon, he refers to the investigations in connection with his paper on "The Influence of Silicon on Cast Iron," published in the "Journal of the Chemical Society," in 1885, when he discarded the old method of deducing from the analyses of samples produced in actual practice, and adopted what he terms the synthetical method. In this method cast iron was first specially prepared so as to contain as little silicon and other impurities as possible, and then mixed with ferro-silicon, so as to give a graduated series of test bars with definite proportions of silicon, the other elements being kept as nearly as possible constant.

Sulphur, phosphorus, manganese, aluminium, arsenic, copper, and titanium are in turn considered.

Lecture four introduces the reader to the foundry, and explains the general arrangement and the methods of re-melting. Different forms of cupolas; moulds and moulding, both by hand and machine; ladles; fuel for re-melting; chemical and physical changes due to re-melting, and pouring temperatures are treated in this lecture, in addition to sundry common troubles that beset the ironfounder.

The final lecture is principally upon chemical, physical, and thermal tests for cast iron, but also deals with the microstructure of the metal and the condition of graphite in cast iron.

If the lack of lecture-table facilities for illustration have proved a disadvantage in placing these lectures in book form, it is largely compensated for by the manner in which the book is illustrated. Diagrams, drawings, and micro-photographic blocks are freely used to assist the author in his valuable work of aiding the foundryman.

Publishers: Charles Griffin & Company, Limited, London.

THE "DUPLEX" STRIPPING PLATE MOULDING MACHINE.

In the issue for April last, we published some particulars of the above moulding machine. We now illustrate herewith a group of castings made on this machine. Fig. 2 shows the method of stripping outside and inside of moulds for such patterns as pulleys and stop-tap boxes. A and B are bolts which pass through the pattern plate and hold up the plate C, which is the size of the inside of the pattern. When the pattern is withdrawn, C remains stationary, stripping out and holding up the core. The use of this machine saves runner cutting, swabbing the mould with water, rapping of pattern, and hand drawing. Boxes up to 24 or 30 in. square, or 48 by 18 in. by 8 in. of draw can be accommodated.

Fig. 3 shows the machine and a number of patterns, the mould being made without a stripping plate. The four arms shown are for bolting in the slots on the plate for extending the machine when necessary. The machine can be arranged on wheels, so that it can follow the sand as it is used, thus saving the carrying of the moulds from one end of the sand heap to the other.

THE PRODUCTION OF MALLEABLE CASTINGS, BY THE FUSION OF WROUGHT IRON IN CRUCIBLES.*

By Mr. E. C. Ongley, London.

For some time past the attention of all interested in the iron and steel industries has been more than usually directed to the important part which material and properties of material play in all engineering work. The increasing demands made on material by engineers has not failed to impress on metallurgists that increased demands require increased strength of material.

In its endeavours to this end, material is the ever-ready, modest, but faithful, hand-maiden of the engineer, generally bearing the blame when failure occurs, whereas in the case of great success of the engineer in the erection of grand bridges and other important buildings, also in the construction of ships, we hear the praise of the designing engineer, but no mention is made of the work of the metallurgist who has supplied the material enabling him to carry out the designs.

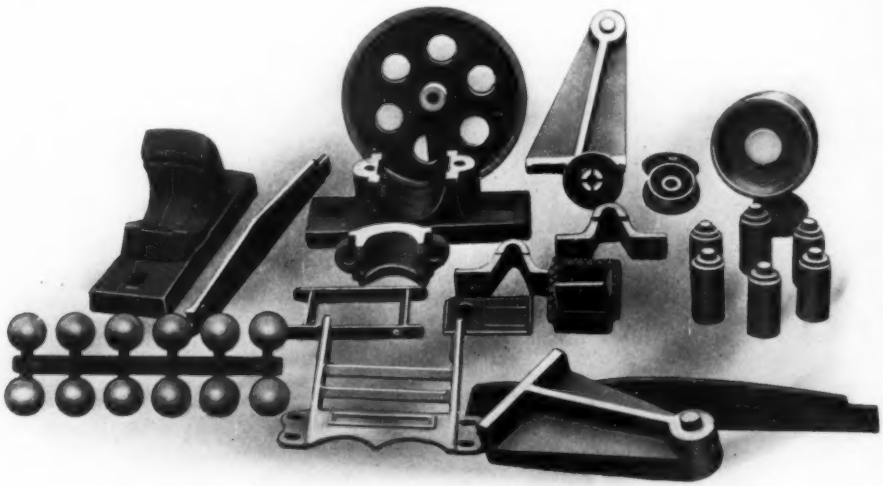

Fig. 1.—Castings Made on the "Duplex" Stripping Plate Moulding Machine.

* Read before the West of Scotland Iron and Steel Institute.

Notwithstanding this want of public recognition, the daily increasing demands of engineers have brought forth many endeavours of metallurgists to provide them with material for their requirements, and we have the spectacle before us of a never ceasing duel between the metallurgist and the engineer, the producer of material, and the user. Extensive research work has been the outcome of this friendly rivalry, stimulating both sides to exert their utmost efforts to keep in the field. This research work has been directed to ascertaining the effect of

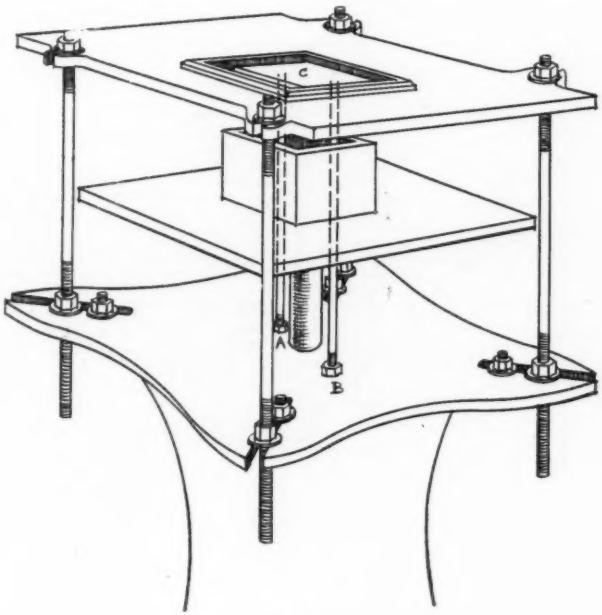

FIG. 2.

various metals on the elastic, tensile, and breaking strain of iron, and on the alloys formed by its being connected with these other metals. Iron is, when shaped by fusion, used in its two forms as cast iron and steel. Castings of the first metal are brittle, whereas steel is hard, not subject to breakage, but hard and rigid. Cast iron can be brought into any shape the engineer may require; it cannot, however, be entirely relied on, and where reliability is essential, steel has to be employed. Between the cheap castings of cast iron and the more expensive steel castings, there is a great gap, which might well be filled up by a new process, and this paper proposes to point out the advantage of this new process for producing malleable castings and steel by the fusion of forgeable iron. At the time of Mushet, to melt wrought iron was, according to Jeans in his book on "Steel," considered impossible. This new process shows it is possible, and is evidence, moreover, of the success attending the research work of iron and steel industries, and also of the possibilities of fusing wrought iron.

In striving to provide material of the required high strength, very numerous experiments have been carried on with a view to producing material which could be used for making castings with properties between those of cast iron and steel; that is, they were to have the properties of forgeable, weldable, malleable iron equal to ordinary wrought iron and mild steel, and, if required, to cast steel. These castings would be available for use in the place of cast iron, and also of forgings, especially repeat forgings, possessing, however, the reliability of forged material. Numerous experiments were made for this purpose, including amongst others the fusion of wrought iron, and

wrought iron scrap in crucibles; the addition of certain special ingredients to the metal when in a molten state, producing material which satisfies the foregoing requirements, and on further development this "flexilis" crucible process was established and may be considered to have fully justified the hopes placed on it.

Process.

This new process has, therefore, for its object, as stated before, the production of a metal for making castings, with the properties of forged iron, but able, when fused, to be cast into moulds producing castings with a carbon percentage of 0.05 to 0.07, and also of steel. The raw material, scrap, and wrought iron, consisting of scrap nails, bolts, chippings of plates and punchings, is filled into crucibles of plumbago with covers, and is then placed on a disc pedestal resting on the fire bars of the furnace, which is then filled with coke. The four-cornered shaft furnace has a double iron casing and is lined with fire bricks; the blast is heated by circulating in the hollow space round the hot furnace, which is placed in a pit. The process of fusion of the first charge requires about two hours from the time of lighting up, whereas the following charges are ready for casting in about 1½ hours. The standard furnace is dimensioned so that it can take four crucibles of 100 lbs. capacity each, and with four charges daily the weekly output of one furnace would be about three tons of castings, as castings, or in the shape of ingots. Five or more charges would increase the output. The waste is very inconsiderable, but the marketable product is about 65 to 75 per cent. of the raw material, the gates and runners, which can be re-melted, making up the 100 lbs. of each crucible. When the melting process is completed, which can be ascertained by a testing rod after the crucible cover has been taken off, the molten material appears quite white, sometimes slightly boiling, but on the addition of certain materials it is at once quieted, and must be then poured into the mould with as little delay as possible, as the high temperature of about 2,700 degrees F. of the metal is an essential feature for the success of this process. The castings, having become cool, can be knocked out of the moulds and need not undergo the process

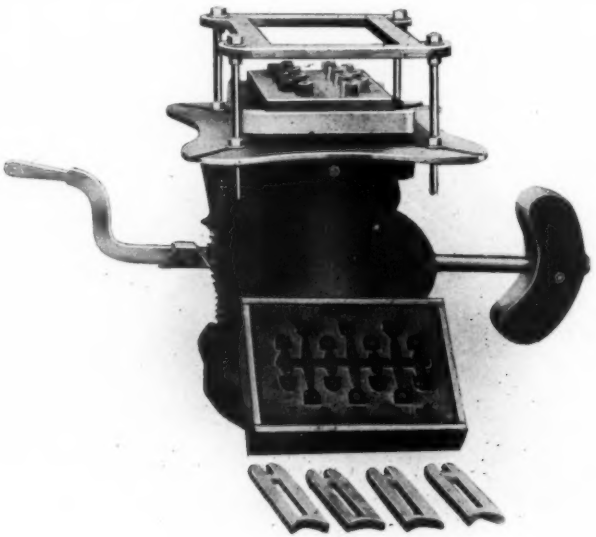

FIG 3.

of annealing, as they are in every respect malleable, and at once ready for use.

Sand.

The sand of the moulds, by a suitable addition of refractory materials, ganisters, etc., is prevented from burning on, so that the castings have a smooth, clean surface, and are also sound, free from blow holes, and perfectly homogeneous.

Temperature.

The temperature of 2,700 degrees F. must be uniformly maintained to secure the fluidity of the metal so that it can run out into the finest lines down to $\frac{3}{16}$ of an inch of any pattern, of machine parts, of boiler fittings, valves, etc., which can thus be made lighter than is possible with any other metal with such high tensile strength.

Cost of Production.

The cost of production of the metal by this new process is low, as it depends on the price of a raw material which is a by-product of engineering work and which, as before stated, consists entirely of waste and scrap of malleable iron and mild steel containing 0.05 to 0.2 carbon percentage; besides this, the cost of the plumbago crucibles—which are good for four or five charges, the consumption of fuel, the wages of the furnace attendant, the additions and general expenses make a total cost of about £10 to £12 per ton for the material as it runs out of the crucibles into the moulds. The wages for moulding have to be added to this.

General Arrangement.

The general arrangement is very simple, and requires no special supervision as the attendance of the furnace can be undertaken by any ordinary labourer after a short course of instruction.

Plumbago Crucibles.

The use of plumbago crucibles is essential, as the temperature is too high to allow clay crucibles used in steel melting to be employed. If this were possible the process might be carried out in the steel pot furnaces.

Blast.

There is a blast required of 10 in. water column, which would be provided by the foundry fan or by a special fan of 18 in. diameter, running at 2,500 r.p.m., requiring 3 to 4 h.p. for one furnace.

No Anneal.

The castings that are produced by this process can, as before stated, be at once used without undergoing the process of annealing, as they already have all the properties of forged iron, with a percentage of carbon ranging from 0.05 to 0.7, thus showing that these in reality consist of forgeable iron which has been shaped by fusion, exactly like other castings and by being then poured into moulds.

Some results of these tests are as follows: —

	Tensile Strength per square inch. Tons.	Elongation in per cent. of test (long bars of 3½ inches.) Per cent.
Forgeable quality	22	32.3
Forgeable and weldable quality	23	32.2
Mild steel	24 & more	24.3
Hard steel	45 & more	19.5 to 12

Tests.

The properties of these castings can be verified by testing them in any way desired in hot or cold state, by treating them under the hammer, press, or any other tool suitable for this purpose. On being machined it would be found that the surface of these castings does not consist of a hard skin, but is simply of a sound homogeneous material, offering no more difficulty to the cutting tool operating on it than when a forging is machined. The work of machining is much reduced as compared with forgings as the margin for tooling can be made very small in the pattern. A shrinkage of 2 per cent. has to be allowed on the patterns.

The tensile strength of the material of which these castings consist can be made to vary to suit requirements, by adjusting the composition of the additions, which are added to the molten metal.

It is claimed for the material produced by this process that it is more homogeneous and freer from flaws than forged iron, as the production by fusion ensures this more effectually than when the material is shaped by treatment under the hammer, as any slags are eliminated in the melting process of fusion.

In producing this material, the composition of the special additions has to be adjusted to suit the purposes to which the castings are to be applied, which can be of forged iron or steely nature, and this can be done within a very narrow margin as regards tensile strength required. It is usual when forgings have been made for a special purpose to reheat and fit them into the positions they are to occupy, and in exactly the same manner the castings by this new process can be also fitted in, as they are not only malleable but ductile, tough and elastic, and of a very pliable nature.

It is evident that the fusion of the raw material mentioned before would not alone suffice to produce the castings with the properties mentioned, and it will be recognised that the effect of the materials added in this treatment of the molten material is of such a nature that the quality of the material produced is entirely dependent on their composition and amount, etc.

At the present time there are about 18 Continental works using the process for producing castings of the kind mentioned.

Electrical Purposes.

For electrical purposes the material produced by this process secures very important advantages, as the soft quality has a very high permeability and much lower retentivity than cast iron or steel, by which the electrical industries would profit very considerably in using it for field magnets, etc. A larger output with reduced weight can be procured as compared with that obtained by the use of cast iron, or even steel, in the construction of dynamos, etc.

General Application.

Castings by this process are, however, also much in demand for cylinders of motor car machinery, as the metal is very tenacious and never cracks; also for motor pistons made under the draw press, as other metals do not stand the severe treatment of the deep draw press.

The larger proportion of the castings produced by this process can be made use of as parts of machinery for all industries which it would be hardly necessary to enumerate here. I only mention that in the case of machinery for motor cars it is perhaps of greatest importance as it produces material for combining strength and light weight so that these engines can be manufactured of a very much reduced weight for the same power. There is, further, one purpose of the very latest times for which this material can be utilised. Machines might be manufactured so very light as to enable the construction of a motor in which one h.p. would not weigh more than 2½ lbs., a result which would enable its use for airships.

Dynamo castings and motor car cylinders with walls of $\frac{3}{16}$ of an inch (4 to 5 m/m) and others, have the following carbon percentage:—

	Per cent.
Soft dynamo castings ...	0.15 to 0.20 carbon.
Mild steel and forged iron quality...	0.20 to 0.25

Wrought Iron.

It is evident that these castings which in reality consist of fused wrought iron, may be considered equal to forgings, and their use is recommended in the place of forgings, as they have, as already stated, all the properties of forged material. One essential point is that they are produced at a very much lower cost than similar work done by the smith under the hammer. The cost of the additions to the molten metal is also very moderate, being about 6d. to 1s. per cwt., as they can be procured everywhere without the slightest difficulty.

Steel.

It may be contended that these low carbon castings can be considered to be in reality steel, as steel is also produced as a low carbon material, so that some doubts might arise if the material can be called wrought iron. It is deemed by some, as stated above, that wrought iron cannot be melted at all, and claimed that malleable iron which is melted must be considered to be steel. It is well known that Mushet's first patent was to melt malleable iron scrap in crucibles, but in his case this was transformed into steel by the introduction of carbon into the crucibles. The name of steel, as applied to iron and its alloys, has been the cause of various suggestions being made to definitely settle what is entitled to this name and what is still wrought iron.

These suggestions have been based on the percentage of carbon, the breaking strain, or the mode of production, etc., but none of them found universal acceptance, so that there is no precise definition of the material steel up to the present time.

One of the most widely spread ideas is that if material can be hardened, it is steel, whereas iron cannot be hardened, and this popular belief can be proved by taking a piece of iron metal to any ordinary smith asking him if it is iron or steel. He would then at once heat it, and see if it can be hardened, and give his opinion accordingly. I mention all this with a view of showing that these low carbon castings may be considered to be really consisting of a material exactly equal to forged iron, although perhaps containing a percentage of carbon as in steel, but the mode of existence of this carbon is different in wrought iron and steel. It is generally accepted that the effect of annealing, that is, to make castings forgeable, is to make the carbon pass from the hardening to the carbide form.

It is very difficult to give the exact

position of these two metals as regards each other, as wrought iron passes quite insensibly into conditions which would make it considered to be steel. The various problems regarding the iron in its alloys and modifications, by perseverance on the part of the metallurgist have given rise to the process I am bringing before you, tending to reach the goal indicated as long ago as 1880 by the then President of the Iron and Steel Institute, Mr. Williams, in these words:—"Then will be produced with absolute certainty, with comparatively light labour, and with fair profit to all concerned, every kind, variation, and quality of the metal iron," which this process claims to fulfil.

It will be seen that the real foundation of all progress is based on the research work of the metallurgist, by whose work also this new kind of low carbon malleable castings has been made possible.

The use of this new process for the production of malleable castings by the fusion of wrought iron scrap in crucibles has, of course, some limitation in the weight of the castings to be produced by it, so that it appeals generally to the manufacturer of moderately-sized castings.

It secures, however, to those manufacturers who introduce it into their works an easy and prompt means of producing their own malleable castings from their own patterns, in which case they need not trust their patterns to strangers, obviously a great advantage to manufacturers of specialities.

Open-Hearth.

Although the chief object of this paper is to bring before you the production of malleable castings, and of steel by the fusion of wrought iron scrap in crucibles, I would like to mention that this process can also be carried on suitably modified in an open-hearth furnace of special construction in which gas firing can develop its heating power in such a manner that wrought iron scrap can be made to fuse very rapidly.

A separate gas producer using the cheapest fuel produces the gas required for the purpose mentioned, and is conducted to the furnace in iron pipes. This special open-hearth furnace can deal with, say, a first charge of 10 tons in about four hours, the following charges much quicker, when a bath of molten wrought iron is ready for tapping.

The raw material in this case is of a more promiscuous quality, consisting of crop ends of rails, bars, drillings, shavings from tool machinery, punchings, bolts and nuts, etc., and every conceivable quality of wrought iron waste which can be thrown on to the hearth, where it at once disappears in the molten bath under the influence of the heating gas flames.

The attendance of the furnace requires three men who are well occupied in bringing along the raw material, the gas producer only requiring one fireman.

The quality of the metal of one ladle from the same charge may be made suitable for the propeller of a ship, another for stern posts and stems, and a third for steam rollers, etc., thus making it possible to satisfy various demands at very short notice from the same charge. The furnaces can be constructed of any size required up to 50 tons and more.

These castings also do not require annealing before they are taken into use. The cost of production by this process is very low indeed, so that a very high profit can be obtained by its use. The approximate cost is £4 to £7 per ton, dependent on the work being by night and day, or only by day.

Referring to the above, it will be recognised that the crucible process adapts itself more to castings of limited size, enabling, however, the manufacture of material of very high standard which is able to cope with the most exacting conditions of the engineer, as regards malleable or steel quality.

The second kind of manufacture by this process, using the open-hearth furnace is more suitable for the production of large quantities of casting as their weight can be quite unlimited for the open market, but also in this case they can be made having the exact properties of forged iron or steel to suit the purpose for which they are intended.

I mention here the importance of this circumstance in the manufacture of large gas engines, referring to the words which were latterly spoken by the well-known expert and President of the Institution of Civil Engineers, Sir William Matthews, who, in his presidential address, mentioned that the manufacture of gas engines of large power was labouring under great difficulties, as the material at present at the disposal of the engineer is not able to withstand the high and rapid changes of temperature. His remarks on the subject were as follows:—

"A difficulty of producing large power by internal combustion arose from the unreliability of cast iron and cast steel in withstanding serious and quick changes of temperature. Large cylinders applied to this purpose had had disappointing results in consequence of destructive cracks which

had developed from this cause. It was likely, however, that engineers and metallurgists working together would solve the problem, and so produce castings improved either in material or form, which would stand the high impulses and wide variations of temperature which had to be encountered when fuel, in both liquid and gaseous form, had to be used for the development of great power on board ships. If the solution of the problem is to be found in a new form of cylinder, no objection to the combination of engineer and metallurgist can be urged. If, however, the solution is to be a new material, the first cost of the marine internal combustion engine may conceivably be raised to such a height that the existing economy in small units of the internal combustion over the steam engine will not be very marked, if at all."

Sir William Matthews seems to consider that the co-operation of engineer and metallurgist would give favourable results. He has, however, great misgivings that the metallurgist working alone would only succeed in providing a metal too expensive for use.

What has been said about the castings produced by the fusion of wrought iron seems to show that this material would be able to satisfy the higher requirements for the purpose mentioned, on account of the qualities which I have explained; the castings are, in fact, so tough that cracks are of very rare occurrence.

These castings have, as compared with annealed malleable castings, the greater strength and the entire reliability of forged material, and as compared with steel castings they are more pliable, free from tensions, and can be made at less cost, and are suitable for use in places where steel castings are rigid and hard and cannot be made light enough, as steel does not run into thin patterns of $\frac{3}{16}$ of an inch. I have endeavoured to show that the properties of material also are generally more important, and in support of this I would like to quote some words of Sir W. C. R. Austen in his "Introduction to the Study of Metallurgy," showing the importance which he attaches to the properties of iron and steel:—"Our national existence depends on iron and steel. They have been the source of our wealth, the main element of our strength, and the cause of our maritime supremacy! Hardly any step towards progress has not been influenced by the properties of iron and steel. It is essential that the significance of this fact should be clearly understood."

In these words lies the invitation to keep up these properties, to increase their value, that is, to cultivate research work in metallurgy, research work which has led also to this "flexilis" process.

The aim of all research work, and of this new process must be to produce material of the highest standard, as near to perfection as possible; that is, material which unites the greatest strength with the least weight, and is the most suitable for the use to which it is to be applied.

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PIPE CONNECTIONS.

CAST iron is probably more extensively used for the manufacture of pipes than for anything else, and there are few foundries that are not called upon from time to time to make pipes in some form or other. The subject of pipe-founding is a very large one, so for the moment we will confine our attention to the preparation of the patterns for the lighter classes of pipe work, showing how some improvements might be effected on methods generally adopted, by a little forethought at the initial stage when preparing the patterns for the various pipe connections.

In order to carry on a successful trade in pipe-founding, it is necessary to have on stock a large number of patterns for the various connections, from which bends, branches, etc., to different angles and shapes may be made as required.

Unless some well-defined system be adopted when preparing these, the founder will find his stock of patterns multiplying in no small degree, involving a large amount of sunk capital from which there may be little return. In a great many cases the number of these patterns can be reduced to a minimum, by making them in such a way that their parts are interchangeable.

It may be stated here that for this class of work "shell" patterns are used, a joint being formed at the parting line, and made to leave their own cores, the whole mould, including the core, being made in green-sand.

Fig. 1 shows a plain bend made up of interchangeable parts, marked A B C, with joints at X X and Y Y. If this pattern be wanted with an inspection door the piece B is removed and a piece D prepared with a door takes its place, as shown in Fig. 2.

To obtain a pattern to the reverse hand, alter the position of A to that of

C, and C to that of A, as shown in Fig. 3.

A further development of this principle is shown in Fig. 4, which shows a pattern of a pipe bend made up of seven pieces, and with the joints properly arranged. No less than 16 patterns of pipe bends to different angles may be obtained from this. The pieces are marked A B E E^1 F G H. The piece H is cut to form an angle of 45 degrees at the centre of its curve, G an angle of $22\frac{1}{2}$ degrees, F to an angle of $11\frac{1}{4}$ degrees, E to an angle of $5\frac{5}{8}$ degrees, and E^1 to an angle of $5\frac{5}{8}$ degrees.

This we admit, and would advise complete patterns being made where there is a "run" on any particular connection, but in many cases the foregoing method may with advantage be adopted.

From the examples it will be observed that by adopting this system of interchanging, with a few pieces of patterns, their joints judiciously arranged, the possibilities are practically unlimited.

It is a common practice amongst engineers and architects, in place of giving the actual angle of a bend, to order them as, "$\frac{1}{4}$ bend," "$\frac{1}{8}$ bend," and so on. As there is sometimes a difficulty

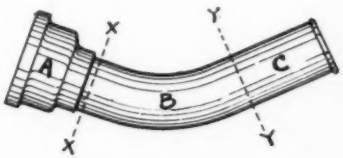


FIG. 1

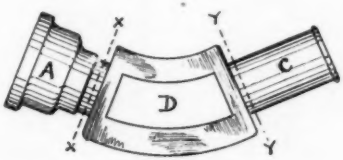


FIG. 2

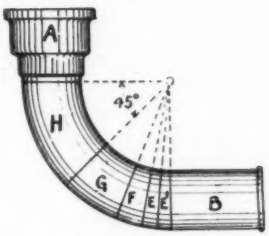


FIG. 4

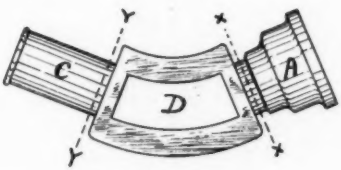


FIG. 3

PIPE JOINTS.

The following are the various combinations, showing the different angles of bends formed therewith :—

Order of pieces.	Angle obtained. Degrees.
AHGFEEB	90
AHGFEB	$95\frac{5}{8}$
AHGFB	$101\frac{1}{4}$
AHGEB	$106\frac{3}{4}$
AHGB	$112\frac{1}{2}$
AHFEB	$118\frac{1}{4}$
AHFB	$123\frac{3}{4}$
AHEB	$129\frac{3}{8}$
AHB	135
AGFEB	$140\frac{5}{8}$
AGFB	$146\frac{1}{4}$
AGEB	$151\frac{3}{4}$
AGB	$157\frac{1}{2}$
AFEB	$163\frac{3}{4}$
AFB	$168\frac{3}{4}$
AEB	$174\frac{3}{4}$

It may be argued that a better casting is obtained from a complete pattern in determining the value of these fractions, the following rule will be found useful.

Multiply the number of degrees in a circle (360) by the numerator of the fraction, and divide by the denominator, then subtract the result from 180, and the answer will give the number of degrees in the bend.

Example :—

Find the angle of a $\frac{3}{16}$ in. bend.

By rule :—

$$180 - \frac{360 \times 3}{16} = \text{angle of bend}$$

$180 - 67\frac{1}{2} = 112\frac{1}{2}$ degrees.

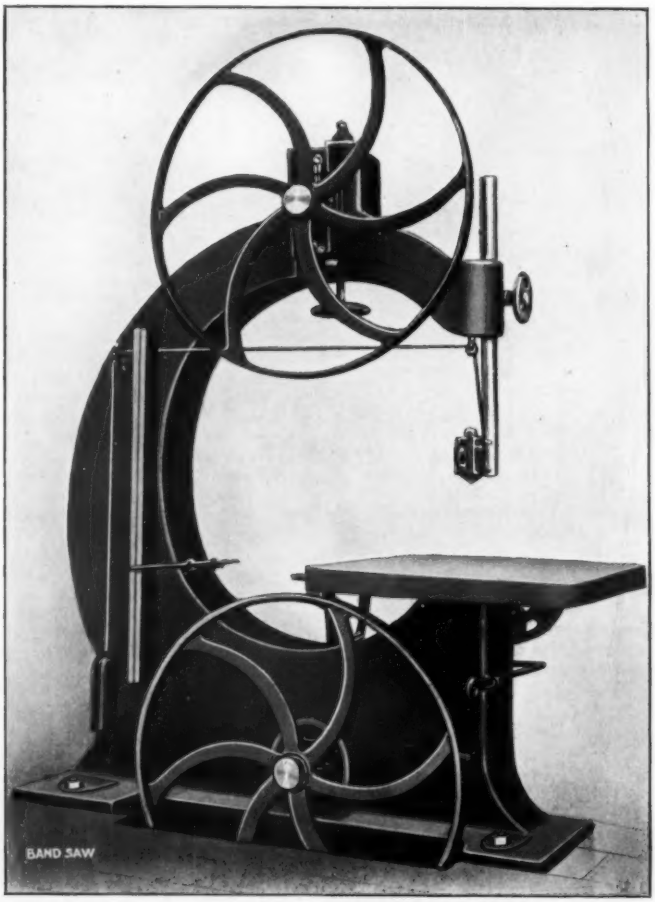
Therefore the angle of a $\frac{3}{16}$ in. bend is $112\frac{1}{2}$ degrees.

We give in handy tabular form the values and angles of the common bends, calculated from the foregoing rule.

Bend.		Degrees.
¼	equals	90
3/16	,, ...	101¼
1/8	,, ...	112½
5/16	,, ...	123¾
⅜	, ...	135
7/16	,, ...	146¼
½	,, ...	157½
9/16	,, ...	168¾
1/32	, ...	174½

A BAND SAW FOR PATTERN-MAKERS.

We illustrate herewith a heavy band saw adapted for use in the pattern-making shop. The main frame is a hollow box casting designed to give rigidity, enabling the machine to run at the highest possible speed without vibration.



It will be noted that all the above common bends can be obtained from the one pattern, as shown in Fig. 4.

The table is truly planed, and will cant for bevel cutting. Both top and bottom wheels are keyed to steel spindles which

run in long white metal bearings fitted with Stauffer lubricators. This method of carrying the top wheel is a great improvement over the old overhung type, which running on a short fixed stud-pin allowed the wheels to quickly wear in the bush, and was, moreover, without adjustment.

The main casting of the machine illustrated is extended to carry a heavy balanced guide arm, to which is fitted a Jackson's patent guide.

We understand from the makers, Messrs. Broom & Wade, High Wycombe, that these machines have run continuously 10 hours a day for a whole year without breaking a saw, and saws $\frac{1}{2}$ in. wide are frequently used on them.

——o——

A COST SYSTEM FOR JOBBING FOUNDRIES.*

THE Jobbing Founders' Association was formed in March, 1906, to ascertain if possible the reason for the wide variation in prices which almost invariably occurred in the jobbing trade and to eliminate, if possible, the apparently general rule of taking work at certain low prices. "because competitors were willing to do so." It was decided to appoint a committee for the purpose of devising some uniform system which could be used in all foundries with a near approach to accuracy and equity. This committee met from time to time during the following year, and, after considering a number of different types, selected, by elimination of what they considered incorrect portions, a rather composite system which embraced the good portions of each. To this they added certain determined upon sections, and then engaged the services of a well-known foundry cost expert to consolidate the different elements into a satisfactory and simple shape. This was done even to the extent of preparing printed blanks for use which would cover every operation of cost keeping.

It was then decided not to attempt to change too much the detail matters of time keeping, billing, shop practice as to how orders should be handled, etc., but to devote the principal effort to the proper division of the elements which constitute a complete cost, allowing each foundry to obtain details as best suited them.

It had been decided that the elements constituting the cost of the foundry product were:—(*a*) productive labour; (*b*) metal; (*c*) expenses, this latter element being divided into three separate and distinct classes; (*d*) productive expenses, which consist of all such expenses as are practically fixed in their nature or not affected by the variation in the amount of production; (*e*) tonnage expenses, which consist of all expenses which are directly affected by the amount of metal produced; (*f*) commercial expenses, which are those directly connected with the sale of the product.

It was also decided that the most equitable way to distribute these various elements of costs was as follows:—(*a*) Productive labour, direct to the product; (*b*) metal, direct to the product; (*d*) productive expenses, on the basis of productive wages expended; (*e*) tonnage expenses on the basis of tonnage or weight of net good castings made.

The sum total of this distribution represents the net shop or foundry cost.

The commercial expenses (*f*), being disconnected with the actual production, it is recommended to distribute over the sales.

In order to show more clearly just which items we considered to be chargeable to productive and which to tonnage expense, I have prepared a "Table of Accounts," showing the make-up of these various elements, which can be sub-divided into as many detailed accounts as may be desired, together with a chart showing the mode of assembling them.

Cost Systems and Management.

To use an expression made by one of the members of the committee, that "no cost system can be of any use unless used with judgment," is to express in a few words that neither this nor any other system can be absolutely depended upon to remedy all the evils of foundry mismanagement, but a proper attention to the various elements of costs here shown, and which are those which comprise the costs of all foundries, will tend to eliminate the great factor of uncertainty now apparently prevalent in many if not all places of our business.

Our committee leaves to each individual the determination as to whether his cost keeping should be considered a part of his general books, but advises its being done. In interweaving this system with the general accounting, it would be necessary to carry a ledger cost account. In

* These particulars of a uniform cost system for jobbing foundries, as recommended by the Jobbing Founders' Association, were prepared and presented before the Philadelphia Foundrymen's Association by Mr. James S. Stirling.

addition to the general ledger it will be found convenient to keep a sub-ledger for the purpose of handling the various sub-accounts of foundry orders, metal, coke, sands, lumber, and other supplies. In the sub-ledger each brand of pig-iron, etc., has its separate account, which is debited with all purchases and credited as used.

Let us assume that we are handed an inquiry, together with a blue print, for a casting. This print is taken by our superintendent, who makes out on the Superintendent's Estimate Sheet his estimate of the time, etc., necessary to produce the casting. This form is given a consecutive number, and provides for a certain description of the proposed casting, number required, weight of each, pattern data, if to be furnished us or an estimate of the cost if we make it, estimate for fixtures, special flasks, etc., and time for moulding, casting, and cleaning, approximate mixture, approximate weight of core rods, runners, gates, etc. This estimate then comes to the office, where the Office Estimating Sheet is made out, which includes expenses, freight or any other charges.

When an order is received it is given a progressive number, these orders being divided into three classes:—(*f*) Orders covering castings for sale to customers; (*e*) orders covering equipment work; (*r*) orders covering replace castings.

These are made out by our stenographer in quadruplicate. One copy is sent to the superintendent, one to the shipping clerk, one to the cost desk, and the other is placed in the office order book and is considered the original. The shipping clerk is also responsible for the proper marking up of the various patterns, gummed labels being used for this purpose.

Our weekly time and pay-roll sheet, which becomes a book of original entry, is what is usually called a "balancing" pay-roll, called so for the reason that the sum total of all charges in the recapitulation columns must exactly agree with the sum of the total wages paid. It is sub-divided into days, and each day into charging columns representing those accounts most frequently used. The time of each employé is collected by the timekeeper, and entered by him in its proper column, the total number of hours at the respective rates counted out and recounted and placed in the total column. The time is then recapitulated, productive labour being put into the productive column and non-productive in the non-productive column.

Our cost sheet especially provides for the proper entries to cover every element which enters into the cost, together with each sale made. All charges for time to the various costs are made directly from the pay-roll to the several cost sheets—one or more being taken out for each order.

These sheets have provisions for showing the various classes of workmen, amount and value of metal, outside purchases, sales or deliveries, etc. At the end of each month the various entries covering expenses are made on these sheets—both productive, which is applied by a per centum factor of productive wages paid and tonnage, which is applied in cents or mills per pound of castings.

Heat Sheets.

As the timekeeper collects the time from the various men he also takes up the heat, *i.e.*, ascertains just how many pieces of each pattern are made by each moulder. This heat sheet is passed to the shipping clerk, who follows up every heat and finds out just what castings are good and what bad. If any are bad he issues a replace or "R" order covering them, and marks the pattern up accordingly. This heat sheet remains with him until delivery is made of the castings, he making a note of delivery by means of a rubber stamp, showing the date delivered. By this sheet we are able to obtain a complete history of any particular order; to ascertain by whom the various castings covered by any order were made; the number defective; and the daily average of each moulder, with the amount of bad castings made by him, together with the reason why castings were condemned.

The Sales Reports are also numbered consecutively, and are so numbered as a check for the bill clerk in invoicing, all numbers having to be accounted for. On these slips we show articles, pattern number, our order number, customer's order and requisition numbers, weight, rate, and amount, with check columns for office use. These are always made out in duplicate, the duplicate becoming a manifest or delivery memorandum for the customer. The foundry memorandum is removed from the copy sent the customer, but the original, which is retained in the office, is used for the purpose of checking up deliveries in the various order books, and for noting that the article had been regularly entered upon the cost sheets.

Additional printed forms are our Material Ledger and Stores Ledger Sheets, Cupola Reports, Daily Report

of Employés and Summary of Completed Costs, the latter showing both the actual and estimated time and value costs.

Various other forms are used for other purposes, such as indexing names and rates of employés, change of rate, shop requisitions for materials, etc.

As monthly reports for comparison, we make summaries of our Cupola Reports, which show the amount melted, ratio of fuel to metal, number of and average size of each heat, proportion of pig and scrap, percentage of loss in melting, pounds of good and bad castings, cost per pound of good castings made for all metal used, expenses which we divide into such items as shown on the table referred to heretofore, proportion of productive to non-productive hours, summary of all costs, showing the profitable and the unprofitable jobs at a glance, and on our own work, showing cost per pound for productive wages, productive expense, tonnage expense, core rods, fixtures, and metal; that of productive wages being further sub-divided into the various classes of workmen to keep in touch with variations, etc.

We close our books every month, taking off a regular trial balance and statement of assets and liabilities, showing accounts receivable and when due, as well as accounts payable.

Method of Handling Metals.

A description of our method of handling metals may be interesting. For convenience, and to be able to keep properly in touch with our various lots, we abandon the brand name and substitute an analysis number. Each car of iron as soon as received is separately piled, numbered, sampled, and analysed, and thereafter that particular pile is not known as No. 1 X Crane or Thomas, but as No. 126, or whatever its analysis number is, and as No. 126 it is weighed and charged into the cupola and reported on the daily cupola report. At the end of the month, if this entire pile is used, No. 126 in the sub-ledger should balance itself; if it does not balance we force it by either debiting or crediting the difference, so that we include the total number of pounds and total value as purchased and paid for in the "Cost of Metal."

This same "overs and shorts" method is used in charging all of our various supplies. By this method we are able at any time to inventory our stock.

Too much cannot be said of this method with the expense materials, such as sands, gravels, etc., which are affected by moisture, as it is necessary to know that every dollar expended for them has been charged to expenses. With these articles we endeavour to keep daily and monthly records of what is used, making sub-ledger entries and expense charges at the end of the month, verifying the inventory by estimating when the material has not all been used and by arbitrarily charging or crediting when the bins are empty or approximately so.

All core rods are weighed each day, and the weight is charged to the respective orders. The labour of making them is considered productive, and as such is charged direct to the order. The metal is charged at the monthly rate of "Cost of Metal," and the job is credited with the scrap value.

All gates, runners, sprues, etc., are gathered up as far as possible each day, particular care being taken to clean up at the end of the month, and the "Foundry Scrap Account" is charged with them ("Cost of Metal" being credited) at a price determined in accordance with the market price of bought scrap. When used over again this sub-ledger account is credited and it again enters "Cost of Metal."

"Bought Scrap" is another sub-ledger account, being charged with all purchases and credited with amounts as reported from cupola. This same evening up process is used here as before described, though owing to its nature it is more dependent upon estimate than the other commodities.

Wasters.

Condemned castings are divided into two classes, those which are condemned in the foundry before entering into sales and those returned by customers. The former class is treated as foundry scrap, the latter as bought scrap. In both cases the cost of making the replace casting, *i.e.*, the labour on it, becomes non-productive labour and is charged to expenses. The metal of this replace casting, which becomes a "sales" is charged to the original order at the "Cost of Metal" price. Here we admit a certain inequity, as the first casting, if condemned in the foundry, does not specifically reach the sales, but is taken up in the "Cost of Metal," whereas, if it is condemned after delivery, the original order has to stand the cost of metal on the replace casting, as well as the difference between the original cost of metal price and the scrap value of the returned casting.

We deem it correct to consider the cost of making replace castings to be an ex-

UNIFORM COST SYSTEM FOR JOBBING FOUNDRIES.

TABLE OF ACCOUNTS.

A PRODUCTIVE LABOUR.

1 All wages (day, piece, or premium) paid to the following when working directly upon production:
Moulders
,, Apprentices
Moulding Machine Operators
Core Makers
,, ,, Apprentices
Helpers or Labourers
Flask Fitters and Carpenters
Casting Cleaners

B METAL.

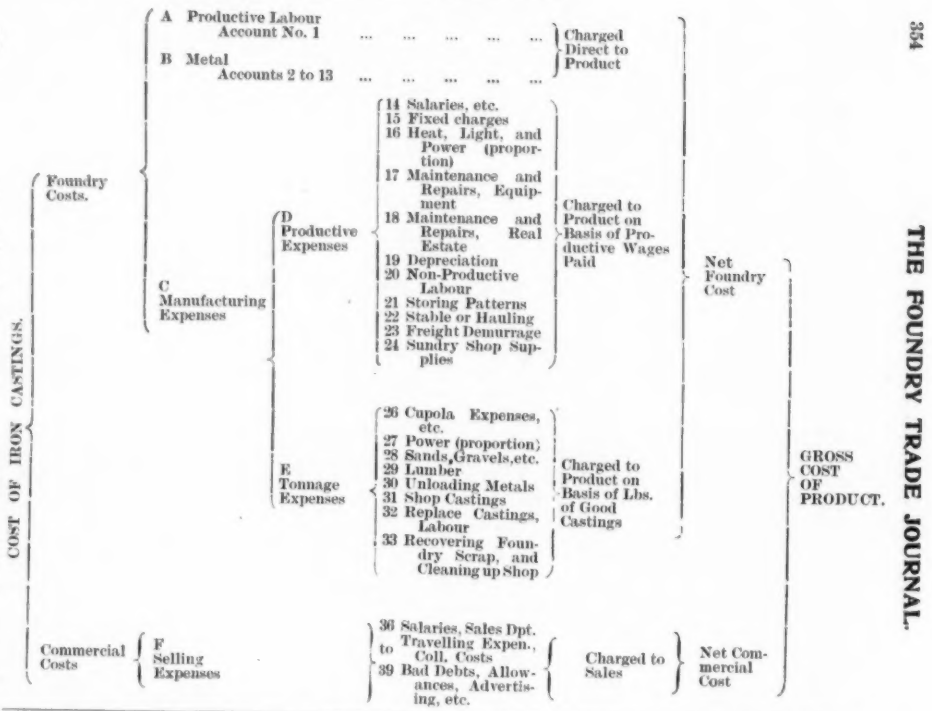
2 . . lbs. Pig-Iron charged into Cupola @ . . 8. .
3 . . lbs. Bgt. Scrap ,, ,, ,, ...
4 . . lbs. Fdy. ,, ,, ,, ,, ...
5 . . lbs. Total Melt 8. .
6 . . lbs. Fdy. Scrap Recovered @ . . 8. .
7 . . lbs. Defec. Cstgs. cond., in Fdy. . . . .
8 . . lbs. Total Scrap Recovered . . . . . .
9 (5—8) Gross Metal Used . . .
10 . . lbs. Net Good Cstgs. (Inc. Core Rods) . .
11 (9—10) Loss in Melting
12 (Value of 9 ÷ lbs. of 10)=Cost of metal per lb. of Good Castings
13 . . lbs. Net Good Cstgs. exclusive of Core Rods, Replace and Foundry Castings

D PRODUCTIVE EXPENSES.

14 Salaries of Officers, Supt., Foreman, Chemist, Clerks, Watchman, Stationery, and Office Supplies.
15 Taxes, Fire and Liability Insurance. Rent or Interest on Investment, and all other fixed charges. (To be prorated monthly.)
16 Light, Heat and Power (except where otherwise shown) including Electrician, & Crane Operators.
17 Maintenance or Renewal of Equipment.
18 Maintenance or Renewal of Real Estate.
19 Depreciation of Real Estate and Equipment. (Pro rate monthly.)
20 Labour of Patt. Maker, Carpenter, Blacksmith, or all other organisation labour not applied direct.
21 Storing and caring for patterns.
22 Stable or Hauling Expenses
23 Freight demurrage.
24 Sundry Shop Supplies.
25 Total Productive Expense.—25÷1=Productive Expense Rate to be applied to direct costs in proportion to amount of direct wages paid on each.

E TONNAGE EXPENSES.

26 Cupola Expenses — Including all labour and material on Cupola and Ladles, relining, charging stock, etc., together with Fuel for Melting.
27 Power—Proportion of power for blowers, elevators, rumblers, pneumatic or hydraulic service to be estimated on horse power basis or obtained by meter.
28 All Sands, Gravel, Facings, Coreroom Supplies, Chaplets, etc., Labour mixing facings and core sands, oven fuel, charcoal, etc.


COST OF IRON CASTINGS.
Foundry Costs.
A Productive Labour Account No. 1 ... ...
B Metal Accounts 2 to 13 ... ...
Charged Direct to Product
C Manufacturing Expenses
D Productive Expenses
14 Salaries, etc.
15 Fixed charges
16 Heat, Light, and Power (proportion)
17 Maintenance and Repairs, Equipment
18 Maintenance and Repairs, Real Estate
19 Depreciation
20 Non-Productive Labour
21 Storing Patterns
22 Stable or Hauling
23 Freight Demurrage
24 Sundry Shop Supplies
Charged to Product on Basis of Productive Wages Paid
E Tonnage Expenses
26 Cupola Expenses, etc.
27 Power (proportion)
28 Sands, Gravels, etc.
29 Lumber
30 Unloading Metals
31 Shop Castings
32 Replace Castings, Labour
33 Recovering Foundry Scrap, and Cleaning up Shop
Charged to Product on Basis of Lbs. of Good Castings
Net Foundry Cost
Commercial Costs
F Selling Expenses
36 Salaries, Sales Dpt. to Travelling Expen., Coll. Costs
39 Bad Debts, Allowances, Advertising, etc.
Charged to Sales
Net Commercial Cost
GROSS COST OF PRODUCT.

29 Lumber for renewing or barring Flasks.
30 Unloading all materials, loading or charges on Refuse Dirt.
31 Labour and metal for shop castings, Jaggers, etc.
32 Labour on replace castings.
33 Recovering Foundry Scrap, Cleaning up Shop.
34 Total Tonnage Expense—34 ÷ 9 (weight)=Ton. Exp. per lb. of good castings to be applied to direct costs in proportion to net wages of good castings in each.
35 Total Foundry Cost—1+9+25+34.

F COMMERCIAL EXPENSES.

36 Salaries of Sales Dept. or Commissions paid.
37 Travelling or Incidental Expenses.
38 Advertising, Catalogues, and other printed matter.
39 Allowances, Cost of Collections, bad debts, Int. on borrowed money
40 Total Commercial Expenses—To be distributed over sales.
41 Total Gross Costs—35+40.

pense of the operation of the foundry, and not a legal charge to the direct production of the order. However, we admit that in certain classes of work there is more chance of having defective work than in others, but we contend that this condition is one for consideration in the acceptance or rejection of an order and in the price consideration. Here will be found one of the applications of the use of costs with judgment—to know that certain work is more hazardous is to know that your expense rate will be affected to a greater or less degree by the amount of bad work made, and if comparisons are continually made of expense sheets the man responsible for the output will naturally be on the alert to exercise all precautionary measures to avoid these losses.

Equipment Expenditure.

All expenditures for additional standard equipment belong to capital account and are properly charged to it at cost value. All renewals to equipment are chargeable to Expenses (Productive), or if any equipment is abandoned or sold, capital account should be credited and expenses charged the full amount, less scrap or sales value.

Regarding special equipment for the production of any particular orders, such as loam plates, special flasks, bars, etc., the proper and only place to charge them is to the order for which they were made, crediting this order with their scrap value upon completion.

Stock cores should be considered a storeroom article, to be charged per piece as used, or if the character of work done is constant or approximately so, it could be considered as a portion of Tonnage Expenses, and so prorated on all orders.

This system, being elastic, it is capable of being divided and sub-divided into many details, or of being condensed into few generalities. If it is found desirable to know the cost per pound or the cost per productive hour of the moulding, coremaking, cleaning, etc., it can easily be done. If it is desirable to know how much per pound of net good castings sold it has cost for any one of the numerous expense items, it can as readily be done and a careful compilation of these details for comparison from month to month will enable you to place your finger upon leaks or apparent wastes. It can be applied to each individual order or to various classes of castings and will be found elastic enough to cover any desired feature.

The attainment of costs does not effect any economy in current production, but it does directly affect profits by showing where losses have occurred either in the too expensive cost of production or too small amount received for the product, and is invaluable as a record for future guidance. With this system it is possible to discover just which of the various classes of work are profitable and which should either be raised in selling price or passed on to your competitor, and also to keep track of the efficiency of your men and organisation.

Different foundries will have different ways of attending to the details of their business, and upon these details we do not presume to pass judgment, but merely present for their consideration this system which provides for the covering of all expenditures incident to the production of castings with the principal desire that ultimately, and if possible in the very near future, we may each and all realise what constitutes our costs, and in realising have backbone enough to turn down an order which our judgment or records show would incur a loss. If this is accomplished, and we compete for work, each will feel that the other is estimating upon the same work from the same standpoint of as nearly accurate costs as seems possible.

Estimating.

This is probably the most particular element in the management of our business, and the most particular element in estimation is to be sure that every item in the cost of production has been included.

We, in the foundry business, are compelled in strictly new work to rely upon the judgment of a guesser, sometimes good, sometimes bad. Where the same thing has been made before, and the former cost is before you, it is somewhat simple, but, even then, due to the fallibility of man, the cost may be incorrect and a careful examination of it should be made. "A good guesser is much more to be desired than a poor estimator," therefore, particular attention should be given. We believe that the proper way to prepare an estimate is to have printed forms calling for every class of work or expenditure, the use of which would seem to make certainty doubly sure. In the use of expense ratio in estimating, judgment should be used in taking as a factor a rate which covered a period as nearly similar in conditions as possible, bearing also in mind the effect the proposed work might have upon the conditions then existing.

This paper, which I trust has presented to your minds a concrete, plausible and

equitable system of cost accounting, will repay me for my efforts many times over if it shall chance to be the means of our getting closer together in the operations of our business. It will have done its duty if it is able to show you how necessary it is for you to know with some approximation of certainty just what it costs you to make all of your castings as a group or all as sub-divided into classes or as further sub-divided into individual items; and that in having this information we can all use it with the determination to make only those castings which will enable us to deal justly with our customers and ourselves, giving them low prices on low cost material and high prices on correspondingly high cost material and wipe out forever the apparently ever-present "hit or miss" custom which seems now to prevail.

——o——

CORRESPONDENCE AND QUERIES.

———

SILICON.

To the Editor of the FOUNDRY TRADE JOURNAL.

SIR,—I wish to purchase some silicon, but am at a loss to know where it can be bought. Will you supply me with the necessary information and the price per lb.

Yours, etc.,

"C. P."

———

POTS FOR MELTING STEEL.

To the Editor of the FOUNDRY TRADE JOURNAL.

SIR,—We shall be glad if you will put us in touch with your correspondent "Clay," with a view to supplying him with fireclay for making pots, etc.

Yours, etc.,

E. J. & J. PEARSON, LIMITED,
Stourbridge Fireclay and Firebrick Works, Stourbridge.

———

SHRINKAGE ON CAST IRON PIPES.

To the Editor of the FOUNDRY TRADE JOURNAL.

SIR,—As a subscriber of your journal, I venture to ask if you or any of your readers could give me any information about the shrinkage on straight cast iron pipes. The pipes in question are as follows, viz.: —

(1).—7 ft. 1½ in. long, 4 in. bore, 5 in. outside dia., 8½ in. flanges × ⅞ in. thick.
(2).—6 ft. 9 in. long, 6 in. bore, 7½ in. outside dia., 11 in. flanges × ⅞ in. thick.
(3).—3 ft. 8 in. long, 6 in. bore, 7½ in. outside dia., 11 in. flanges × ⅞ in. thick.
(4).—5 ft. 7 in. long, 6 in. bore, 7½ in. outside dia., 11 in. flanges × ⅞ in. thick.
(5).—4 ft. 8 in. long, 6 in. bore, 7½ in. outside dia., 11 in. flanges × ⅞ in. thick.

These wood pipe patterns, having been measured up with a contraction rule, and ⅛ in. extra allowed on each flange for machining, when cast and measured up, we get the following lengths, viz.: —

(1) 7 ft. 1⅛ in. long, (2) 6 ft. 9 in., (3) 3 ft. 8⅛ in., (4) 5 ft. 7 in., (5) 4 ft. 8 in.

Hoping I may have the pleasure of obtaining some information.

Yours, etc.

"INQUIRER."

———

FLUX FOR MILD STEEL CASTINGS.

To the Editor of the FOUNDRY TRADE JOURNAL.

SIR,—If your correspondent "B. S. S." will put himself in communication with us, we shall be pleased to inform him how to overcome his trouble of not being able to get his metal sufficiently liquid.

Yours, etc.,

THERMIT LIMITED.
27, Martin's Lane,
Cannon Street, London.

——o——

BRASS MIXTURE.

To the Editor of the FOUNDRY TRADE JOURNAL.

SIR.—In reply to "A Brass Moulder." the best proportions for fine brass are those of the chemical equivalents of the metals, viz.: 2 copper, 63.3 by 1 zinc 32.57, or about 2 parts copper and 1 part zinc. For rolling into plates or sheets, and for drawing into wire, it is necessary that the brass should be made exclusively of copper and zinc, but a better metal for turning purposes is produced by the addition of about 3 per cent. of lead. From my own experience the above should, other things being equal, get your correspondence out of his difficulty.

C. E. ALLEN.

LIST OF NEW INVENTIONS.

1908.

Specially compiled for the FOUNDRY TRADE JOURNAL by MR. GEORGE BARKER, Fellow of the Chartered Institute of Patent Agnets, Consulting Engineer and Chartered Patent Agents, 77, Colmore Row, BIRMINGHAM.

8,309. C. BURTON. Improvements in moulds for casting links in chain form.

8,341. W. H. B. HATTON. Method of making sound cast steel ingots.

8,692. C. C. G. VIELET Process for converting into steel cast iron, soft steel, cast steel, and the like.

8,881. G. A. OERTZEN. Improved moulding machine for foundry work.

8,981. W. P. THOMPSON. Improved portable moulding machine.

9,057. F. HERBERT. Improvements in and in connection with the use of machinery for forming moulds for casting pipes.

9,137. B. W. HEAD. Improvements in apparatus for stripping ingots of their moulds and for charging ingots into furnaces.

9,205. W. H. CONNELL. Improvements in the method of casting compound ingots.

9,345. A. BAILLOT and J. PARIS. Improvements in the formation of moulds for casting metal and in apparatus therefor.

9,346. A. BAILLOT and J. PARIS. Improvements in moulding machines.

9,383. A. REYNOLDS. Improvements in the manufacture of steel and other metallurgical processes.

10,176. W. L. COOPER. Process for solidifying steel ingots.

10,230. J. H. MONGE. Improvements in or relating to the manufacture of sectional moulds.

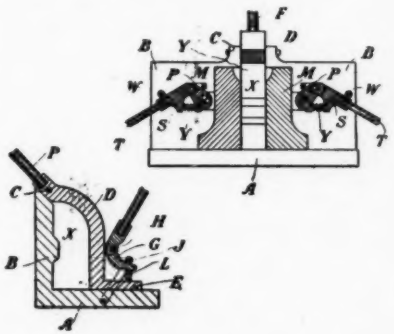
1907.

11,257. J. H. SHAW, New Haven, Conn. U.S.A. Improvements in moulds for casting metals.

This invention relates to moulds for casting metals, and particularly to that class of moulds made from metal.

The object of the invention is to provide a mould which will give as required by the expansion of the casting, and thus prevent cracking of the mould. The object is attained by holding the parts of the mould together in a yielding manner, so that they are capable of a slight movement upon the expansion of the casting while they are still held in position.

With reference to the illustrations, A represents a plate forming the base of the mould, and B an upright plate rigidly secured thereto forming the back plate of the mould. To the top of the back plate is fulcrummed by a pin C a pivoted member D, which, when in proper position, forms the front of the mould. The member D is provided with a flange E, adapted to fit on the bottom plate A of the mould. A handle F is secured to the member D to swing it to and from its closed position. The member D is held in its closed position by a hook G, fulcrummed at H and provided with a handle. The hook G takes into a link pivoted to a projection on the bottom plate A. A spring L bears against the underside of the hook G and against the flange E of the member D to hold the hook in position.



The operation is as follows:—The member D is swung into position by means of the handle F and link J engaged by the hook G. The side plates are then forced against the sides of the member D, leaving between the side plates, member D near plate B and base A, a cavity for the casting poured in through Y. In the side, plates are held in position by the spring V fixing the link P and bar S apart, so that the bar S abutt against the stud W.

When the metal in the mould expands, the member D will be moved slightly outward against the tension of the spring L, which permits the hook G to be slightly turned while still engaged in the link J. The side plates M will be moved slightly outward upon the expansion of the metal in the mould, as the springs V will be contracted and allow the links P to turn somewhat on their pivots, and the lower end of the link and the bar S be brought closer together.

To remove the side plate, it is only necessary to turn the bars so as to swing it away from engagement with W, and the plate may be withdrawn by the handle T.

TRADE TALK.

PETER BROTHERHOOD, LIMITED, have removed to 53, Parliament Street, London, S.W.

THE shipbuilding yard of Charlton & Doughty, Limited, at Grimsby, has been closed.

THE LANCASHIRE WAGON COMPANY, LIMITED, of Bury, is being wound-up voluntarily.

THE BROWN ENGINEERING COMPANY have removed to Dixon House, Lloyd's Avenue, E.C.

LEYLAND MOTORS, LIMITED, have appointed Mr. H. J. Fitton as their representative for the Midlands.

MESSRS. SEVERN & COMPANY, agents for machine-tools, etc., have removed to 20, Budge Row, London, E.C.

MESSRS. COCHRANE & COMPANY, Middlesbrough, are supplying 20,000 tons of cast-iron pipes to the Leicester Corporation.

BEYER, PEACOCK & COMPANY, LIMITED, have removed their London offices from 34 to 14, Victoria Street, Westminster, S.W.

MESSRS. C. H. BAILEY & COMPANY, engineers and ship-repairers, of Barry Dock, are shortly erecting new works facing the No. 1 Dock.

MESSRS. J. BAKER, J. A. BAKER, and W. BAKER, iron founders, Rochdale, have dissolved partnership so far as regards Mr. W. Baker.

MESSRS. J. W. GLOVER & SONS, have acquired the stock, etc., of W. Glover & Sons, Limited, of Warwick, and in future will carry on the business.

MESSRS. E. D. EVANS and J. W. H. EVANS, engineers, Middlesbrough, trading as the Star Manufacturing Company, have dissolved partnership.

MESSRS. H. FOWKES & COMPANY, Wellington Foundry, Derby, have removed their business to the Fowkes & Woolley Foundries, Summerhill, Tipton.

THE STIRLING BOILER COMPANY, LIMITED, have re-opened their Cardiff office at 13, Queen Street, under the management of Mr. S. R. Wallis.

MESSRS. J. F. PHILLIPS and F. J. PHILLIPS, engineers, Brighton, and Old Queen Street, Westminster, London, S.W., have dissolved partnership.

THE LEWIS GAS SUCTION COMPANY, of Llanelly, who have lately patented a new reversible engine, propose to float a new company to build works in the town.

MR. E. C. AMOS, sole British agent of the Swiss Locomotive and Machine Works, Winterthur, has removed to 3, Laurence Pountney Hill, Cannon Street, E.C.

W. MCGEOCH & COMPANY, LIMITED, 28, West Campbell Street, Glasgow, are now the Scottish representatives of the Credenda Conduits Company, of Birmingham.

CIRCULATORS, LIMITED, of Deansgate Arcade, Manchester, have been appointed sole selling agents in this country for the Ashton type of high-speed engine lathe.

MESSRS. E. P. BASTIN, R. S. BASTIN, and F. BASTIN, engineering merchants, Queen Victoria Street, E.C., have dissolved partnership so far as regards Mr. E. P. Bastin.

RICHARDSONS, WESTGARTH & COMPANY LIMITED, of Middlesbrough, have appointed Messrs. Scrivener, Breffit & Company, of Cardiff, to act as their agents in South Wales.

THE business founded by the late Mr. B. H. Thwaite will continue to be carried on by Messrs. Thwaite & Thorp, at 29, Great George Street, Westminster, S.W., as hitherto.

THE NORTON HARTY ENGINEERING COMPANY, of Tipton, Staffs., have appointed as their South Wales representative, Mr. A. A. Cecil Davies, Western Mail Chambers, Cardiff.

A RUMOUR has lately been circulated that a sale of Messrs. Cammell, Laird & Company's Lowther Iron Works was pending. We are informed, however, that the report is without foundation.

WM. BEARDMORE & COMPANY, LIMITED, have just made a start in the new gun factory at their Parkhead Works, on the construction of the first 12-in. naval gun that has ever been made in Scotland.

MESSRS. TAYLOR & HUBBARD, Kent Street Works, Leicester, have supplied a very fine locomotive steam crane for unloading the exhibits in the machinery hall at the Franco-British Exhibition.

THE BRIGHTSIDE FOUNDRY AND ENGINEERING COMPANY, LIMITED, of Sheffield, have established a branch at 159 and 160, Great Charles Street, Birmingham, with Mr. J. Westwood as manager.

MESSRS. MURRAY, LOTZ & COMPANY, of 102, Fenchurch Street, London, E.C.,

have just lately closed a large contract for additional industrial railway plant for a large foundry in the South of England.

Mr. S. T. Pemberton, Council Chambers, 109, Colmore Row, Birmingham, has been appointed Midland Counties' agent of Eversheds & Vignoles, Limited, Acton Lane Works, Chiswick, London, W.

Messrs. Mirrlees, Watson & Company, licencees of the Diesel Engine Company, Limited, have secured permission for the erection of new works in Manchester for the manufacture of Diesel engines.

Messrs. William Wilson & Company, Lilybank Boiler Works, London Road, Glasgow, recently shipped three large Lancashire boilers, which are to be used in connection with the new water works at Osaka, Japan.

The oxy-acetylene process for cutting and welding pipes, etc., is being exhibited by Messrs. Hunter & Swan, engineers, etc., of 1, James Street, Cardiff Docks. The work is done by means of blow-pipes fed by oxygen and acetylene gas.

We understand that the recent decision to ask the shareholders of Cammell, Laird & Company, Limited, for additional capital, will not now be put into force, the finances of the company having now been sufficiently strengthened.

The shareholders of Meldrum Brothers, Limited, Timperley, near Manchester, have decided that, it having been proved to their satisfaction that the company cannot, by reason of its liabilities, continue its business, it be voluntarily wound-up.

The Brightside Foundry and Engineering Company, Limited, of Sheffield, recently completed for a Yorkshire firm a horizontal press for forcing railway wheels on to their axles or taking them off, which has the exceptional maximum power of 300 tons.

The following statement of affairs of Millen & Sommerville, Limited (in liquidation), as at March 28, 1908, was recently submitted at a meeting of the firm's creditors:—Assets, £19,841 7s. 2d.; liabilities, £11,965 13s. 11d.; surplus, £7,875 13s. 3d.; subject to realisation.

Messrs. Hawkins & Company, of Chapel Hill, Huddersfield, have placed on the market an imperishable jointing cement, claiming that it gives satisfactory results for any class of screwed or flanged pipes, cylinders, receivers, feed-water heaters, economisers, steam kettles, radiators, etc., whether used for super heat, steam, water, air, gas, or ammonia.

At the Birmingham Official Receiver's Office, recently, a creditors' meeting was held in the matter of J. F. Wood, iron-founder, of Great Bridge, Tipton. The Official Receiver gave the following particulars:—Partly secured creditors represented £310; unsecured, £546 9s. 1d.; contingent liabilities, £2,313 13s. 4d.; expected to rank, £2,021; assets, nil. The examination was concluded.

PERSONAL.

Mr. R. R. Roberts, owner of the Woolfold Iron Works, Bury, has been made a Lancashire J.P.

The late Sir Charles Edward Howard Vincent, M.P., left estate of the gross value of £64,580.

The gross value of the estate of the late Mr. James Howden, Junr., engineer, of Dowanhill, Partick, is £16,367.

Mr. J. F. Cay is retiring from the active management of the business of the Patent Shaft and Axletree Company.

Lord Claud John Hamilton has been elected a director of Hadfield's Steel Foundry Company, Limited, Sheffield.

Mr. G. Prew, works manager of the Star Engineering Company, Limited, Wolverhampton, is resigning his position.

The gross value of the estate of the late Mr. George Dawson, managing director of Newton, Chambers & Company, Limited, is £31,820 2s. 2d.

Mr. H. Westlake, managing director of the Staveley Coal and Iron Company, Limited, has been elected a director of Cammell, Laird & Company, Limited.

The gross value of the estate of the late Mr. W. Williams, J.P., a director of John & Edwin Wright, Limited, and W. & T. Avery, Limited, is £82,849.

The late Mr. R. Laidlaw, J.P., of the Alliance Foundry and the Broomhill Foundry, Glasgow, left personal estate in the United Kingdom valued at £10,473.

Mr. G. W. Williams and Mr. H. W. Williams have been elected joint managing directors of D. F. Tayler &

Company, Limited, New Hall Works, Birmingham.

Mr. J. Howard Beach has been appointed secretary of the Gloucester Railway Carriage and Wagon Company, Limited, in succession to the late Mr. H. T. Simpson.

The late Captain F. W. Lowther, of the firm of Messrs. Punchard, McTaggart & Lowther, of 151, Cannon Street, E.C., engineers and contractors, left estate of the gross value of £296,578.

Mr. E. F. Lange and Mr. A. C. Rogerson, of Beyer, Peacock & Company, Limited, Manchester, sailed on May 2 for the United States on a tour of inspection of American machine shops and foundries.

Mr. G. E. Drury, managing director of the Trent Iron Works, Scunthorpe, of Messrs. John Brown & Company, has resigned the managership, but retains his seat on the board. Mr. J. E. Simpson has been appointed manager.

Mr. W. T. Batho has been appointed manager of the Diesel Engine Company, Limited, in place of Mr. Browett, who has been transferred to the company's sales and enquiry department. Mr. C. Jeppo has resigned his seat on the board.

Mr. H. W. Dixon, of Messrs. Taylor Brothers & Company, Clarence Iron Works, Leeds, has been appointed by the Carnforth Hematite Iron Company as their representative in succession to Mr. J. Gregory, resigned. Mr. Gregory will remain on the board of directors.

The late Dr. Sorby left £15,000 to the Royal Society of London for the establishment of a fellowship or professorship for the carrying on of original scientific research; £6,500 to Sheffield University to endow a professorship of geology or other subject, and £1,000 to the Geological Society of London.

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DEATHS.

Dr. Hermann Wedding, the well-known German metallurgist.

Mr. T. Cantrell, secretary of the Manlove Engineering Company.

Mr. H. P. Meares, of Mavor & Coulson, Limited, in his 55th year.

Mr. Henry Davies, J.P., of Preston, a director of the Ebbw Vale Steel, Coal, and Iron Company.

Mr. Wm. Spittle, of Messrs. Gough & Spittle, fender manufacturers, Churchfield Street, Dudley.

Mr. T. Lees, of Messrs. T. & R. Lees, Park Foundry, Hollinwood, near Manchester, aged 64 years.

Mr. B. H. Thwaite, consulting engineer, of Great George Street, Westminster, London, S.W.

Mr. S. L. Millington, at one time proprietor of the Summerhill Iron Works, Princes' End, Tipton.

Mr. J. I. Hopper, managing director of the firm of John I. Hopper, Limited, Thornaby, aged 60 years.

Mr. William Inglis, a partner of Messrs. Wm. Bain & Company, Lochrin Iron Works, Coatbridge, aged 52 years.

Mr. J. Aimers, at one time connected with Messrs. Aimers, McLean & Company, Waverley Iron Foundry, Melrose.

Mr. F. H. Webb, for 20 years secretary of the Institution of Electrical Engineers, retiring in 1898, aged 84 years.

Herr Arthur Koppel, head of the well-known engineering firm which was founded in Berlin during the last century.

Mr. George Garrett, who, with Mr. Thos. Davie, founded the Waverley Iron and Steel Works, Coatbridge. He was in his 63rd year.

Mr. C. H. Woodhouse, managing director and chairman of Messrs. Woodhouse & Company, of the Hexthorpe Brass Works, aged 50 years.

Mr. G. Robson, a well-known South Shields engineer, aged 64 years. He commenced business as an engineer and ship-repairer at Tyne Dock over 30 years ago, and in recent years the concern was taken over by a limited liability company.

Mr. C. J. Appleby, M.Inst.C.E., in his 81st year. Mr. Appleby was the founder and senior partner in the firm of Appleby Brothers, which was amalgamated some twelve years ago with that of Joseph Jessop & Sons, trading as Jessop & Appleby Brothers, Limited, which concern has recently amalgamated with the Glasgow Electric Crane and Hoist Company, Limited, and with the Temperley Transporter Company, and is now trading as Applebys, Limited.

FOUNDRY LADLES.

28 LB.
—to—
30 TON.

JAMES EVANS & CO., BRITANNIA WORKS,

TELEGRAMS—
"LADLES, MANCHESTER."
TELEPHONE—2297

BLACKFRIARS, MANCHESTER.

NEW COMPANIES.

WEEKS & COMPANY, LIMITED.—Capital £1,000, to carry on in Birmingham the business of mechanical engineers.

JOHN R. BIRD, LIMITED.—Capital £5,000, to take over the business of John R. Bird, Kingston Engine Works, Glasgow.

ALEXANDER BURTON, LIMITED.—Capital £1,000, to acquire the business carried on by the Star Emery Wheel Company, Glasgow.

ROBERT CORT & SON, LIMITED.—Capital £5,000, to take over the business carried on at the Kennet Iron Works, Reading, as Robert Cort & Son.

JOHN BENNIE, LIMITED. — Capital £10,000, to acquire the Star Engine Works in Glasgow. Registered office: 151, Moncur Street, Glasgow.

THOMAS WHITE & SONS, LIMITED.—Capital £35,000, to carry on the business of engineers. Registered office: Laighpark Engineering Works, Paisley.

L. STEIN & COMPANY, LIMITED.—Capital £12,000, to acquire the iron-founding business carried on at Jaffa, Palestine, as L. Stein & Company.

GEORGE MOULTON, LIMITED.—Capital £20,000, to take over the business of engineer, etc., carried on by W. Moulton at Manchester, as George Moulton.

ROWLAND HILL & SONS, LIMITED.—Capital £15,000, to acquire the business of an engineer, iron, brass, and aluminium founder, carried on by R. Hill, at King Street, Coventry.

PARKER FOUNDRY COMPANY, LIMITED.—Capital £20,000, to acquire the business carried on by H. W. Surtees, at Siddals Road and Mansfield Road, Derby, as the Parker Foundry Company.

DUDLEY TOOL AND IRONWORKS COMPANY, LIMITED.—Capital £2,000, to take over the business of a tool manufacturer, carried on by J. Whitehouse at Tat Bank Works, Oldbury, Worcestershire.

SAMUEL NICHOLLS, LIMITED.—Capital £5,000, to acquire the business carried on at 16, Princip Street, Birmingham, as Samuel Nicholls, and to carry on the business of stampers and piercers, iron founders, etc.

IMESON, FINCH & COMPANY, LIMITED.—Capital £10,000, to acquire the business carried on at Stockton-on-Tees as Imeson Brothers, Finch & Company, and to carry on the business of electrical, mechanical, and general engineers.

FLETCHER BROTHERS (A-U-L) (1908), LIMITED.—Capital £13,275 in £5 shares, to acquire the business carried on at Ashton-under-Lyne by Fletcher Brothers (A-u-L), Limited, and to carry on the business of brassfounders, etc.

JAMES ROBERTSON & SONS (FLEETWOOD), LIMITED.—Capital £25,000, to acquire the business carried on at Fleetwood by James Robertson & Sons, and to carry on the business of marine, hydraulic, and mechanical engineers, etc.

FOWKES & WOOLLEY FOUNDRY, LIMITED.—Capital £5,000, to take over and amalgamate the businesses carried on (1) by D. Green at Tipton, Staffs., as the Woolley Iron Foundry Company, and (2) by C. J. Moore at Derby, as H. Fowkes & Company. Registered office: Summershill, Tipton, Staffs.

RICHARDSON, TUER & COMPANY, LIMITED.—Capital £7,000, to acquire the businesses carried on by W. B. Richardson at Hope Foundry, Farnworth, as Richardson, Tuer & Company, and at Lum Street, Bolton, as Wm. Archer & Son. Registered office: Hope Foundry, Egerton Street, Farnworth, near Bolton.

Ganister, Cupola Blocks, Fire Bricks,
Fire Clay.
Silica Bricks, Tuyeres, Stoppers, Nozzles, &c.
Steel Moulders' Composition, Silica Cement.

J. GRAYSON LOWOOD & Co., Ltd.,
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ELDERS FOUNDRY COKE

As supplied to the British . . Admiralty Dockyards.

The following, selected from numerous letters, are eminent testimony as to the quality of our celebrated "A.A.A." Coppee Foundry Coke, carefully selected, and despatched in sheeted wagons.

From PECKETT & SONS, Bristol.

Bristol, October 25th, 1904.

We have been using your Selected Foundry Coke for some considerable time.

We have pleasure in stating that we are very pleased with it, as we find we get sounder and cleaner castings, more free from blow-holes and other defects, than we formerly did.

From MOUNTFORT PHILLIPS & Co., Llantrissant.

Llantrissant, October 25th, 1904.

In reference to the Foundry Coke you have been supplying us with for the last six months, we have very great pleasure in letting you know that it has given every satisfaction, and that our Works Manager and Workmen give it the highest praise.

Elders Navigation Collieries, LTD. Cardiff.

PRICES OF METALS.

The following table shows the approximate latest prices and position of stocks of metals during the past two years :—

Metals.	1907-8.	1906-7.
Iron—Scotch pig warrants ... ton	*55/9	*67/3
—Middlesbro' warrants ... ton	49/10½	61/3½
—W.C. M/nos Bessemer ... ... ton	61/6	81/0
—Stock, Scotch, May 29 ... tons	1,000	2,820
Copper—Chili bars, GMB ... ... ton	£57 2/6	£99 12/6
—Stock, Europe & afloat... ... tons	28,126	11,603
Tin—English ingots ton	£129 0/0	£194 0/0
—Straits ... ton	£127 5/0	£190 5/0
—Stock, Ldn. Hind and afloat .. tons	—	12,580
Lead—English pig ton	£13 6/3	£20 12/6
Spelter—Ord. Silesian ... ... ton	£19 15/0	£25 0/0
Quicksilver-(75lb.) bottle	£8–£8 2/6	£6 16/0-£7 0/0
Antimony—Regulus ... ... ton	£35 0/0	£75 0/0-£77 0/0

*Settlement price.

Castings.

In the Cleveland district the following are the nominal rates current for castings : —

	£ s. d.		£ s. d.
Columns (plain)	6 15 0	to	7 0 0
Pipes, 1½ to 2½ in.	5 2 6	to	5 7 6
,, 3 to 4 in.	4 15 0	to	5 5 0
,, 5 to 8 in.	4 12 6	to	4 15 0
,, 10 to 16 in.	4 12 6	to	4 15 0
,, 18 to 24 in....	4 12 6	to	4 15 0
Chairs	3 10 0	to	3 15 0
Floor plates (open sand)	3 2 6	to	3 5 0

Scrap.

The quotations for scrap, subject to market fluctuations, are as follows: — Heavy wrought (mixed), £2 7s. 0d.; light wrought, £1 1s. 0d.; heavy cast, £2 6s. 0d.; all per ton f.o.b., London. Copper (clean), £53 0s. 0d.; brass (clean), £41 0s. 0d.; lead (usual draft), £12 5s. 0d.; tea lead, £10 10s. 0d.; zinc, £15 10s. 0d.; all per ton delivered merchant's yard.

SILICA FIRE BRICK Co.,

OUGHTIBRIDGE.

GROUND GANISTER,

Wet or Dry.

Silco Cupola Bricks, 90 % Silica.

Better than Fire-clay Bricks for Cupolas.

Established 1863.

Jas. Durrans & Sons,

PHŒNIX WORKS, PENISTONE, Near Sheffield.

Manufacturers of all

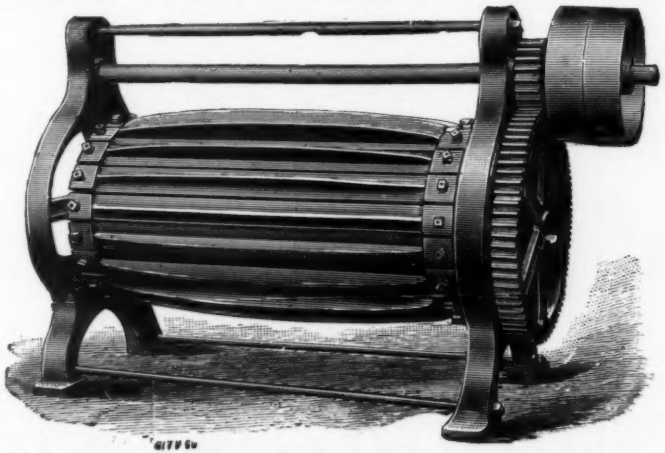
FOUNDRY EQUIPMENTS,

Composition Black Lead,

Plumbago, Core Gum, White Dust, and Coal Dust.

Ladles, Cupolas, Fire Bricks, Gannister, Stone Flux, Loam and Sand Mills, Casting Cleaners, Studs, Chaplets, Pipe Nails, Sprigs, Brushes, Wire Brushes, Core Ropes, Bellows, Buckets, Spades, Forks, Riddles, Sieves, Barrows, &c.

IMPROVED FOUNDRY RATTLER or FETTLING DRUM.

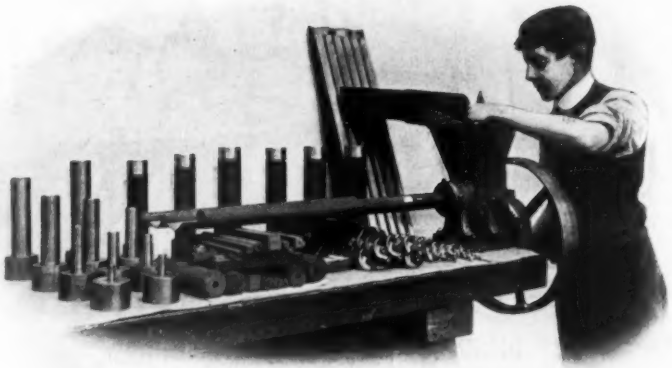


These Machines are invaluable for a Foundry, doing a larger amount of work of a superior quality, in a much shorter time than can be done by hand, without skilled labour.

"Dear Sirs,—We have been using your best Blacking for a large number of years, and always use it on our large Ingot Moulds, which, as you know, we have made up to 85 tons in weight.

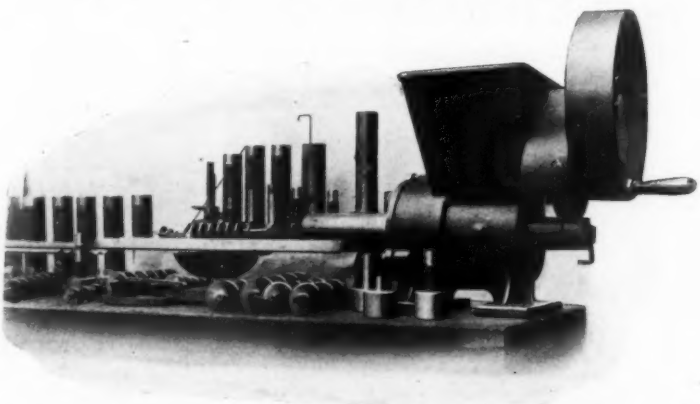
"Yours faithfully, THE BRIGHTSIDE FOUNDRY & ENGINEERING CO., LD."

CORE MACHINES.



No. 1. Small Rotary type, Capacity $\frac{3}{32}$ in. to $1\frac{1}{16}$ in.
No. 2. do. do. do. $\frac{3}{32}$ in. to $2\frac{1}{4}$ in.

No. 3. Large Rotary type, Capacity
No. 4. do. do. do. } $\frac{3}{32}$ in. to 6 in.
No. 5. do. do. do. $\frac{3}{32}$ in. to 7 in.



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PATTERNMAKER, age 21, 7½ years' experience, Steam Engine Patterns, etc.; good references.—P. DAVIS, Bourton, Dorset.

ENGINEER (33) wants SHOP FOREMAN'S or responsible post; Steam, Gas, and Oil Engines, Pumps, Lifts, and General; good foreman's references; abstainer.—Address Box 620, Offices of THE FOUNDRY TRADE JOURNAL, 165, Strand, London, W.C.

WANTED, situation as MANAGER or FOREMAN over Malleable or General Iron Foundry, thoroughly experienced in up-to-date Moulding Machines, Plate, White Metal Oddside, Sprayed Patterns, also by hand; well up in Castings for Cycles, Motors, and Conduit Trade; Annealing, light and heavy, in all kinds of ovens; four years as Foundry Manager; good reference; sober, good timekeeper.—Address Box 621, Offices of THE FOUNDRY TRADE JOURNAL, 165, Strand, London, W.C.

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FOR SALE, PATENT ROOTS' BLOWERS:—

No. 1a size	"Allday's"	6 in.	outlet,	as new.
,, H ,,	"Samuelson's"	7 in.	,,	,,
,, 5a ,,	"Thwaite's"	4 in.	,,	,,
,, 2 ,,	,,	8 in.	,,	,,
,, 4 ,,	"Baker's"	11¼ in.	,,	,,

Three Air Compressors.
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CHEMICAL ANALYSES OF FOUNDRY MATERIAL.

PIG-IRON, BRASS, BRONZES, SOLDERS, COMPOSITIONS, &c.
Standard Methods. Prompt dispatch of results. Special Contract Charges.
CHEMICAL & ASSAY LABORATORY,
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THE Proprietors of the PATENT No. 17,117 A.D. 1904, entitled "AN IMPROVED METHOD FOR PROVIDING HOLLOW WROUGHT IRON BODIES WITH LININGS OF CAST METAL," desire to grant Licenses to interested parties. Enquiries to be addressed to CLEMENT LEAN, B.Sc., A.M.I.Mech.E., Chartered Patent Agent, Thanet House, 231, Strand, London, W.C.

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FOR SALE.—One Baker's Patent Rotary Pressure BLOWER, with iron revolvers, size 25, with Steam Engine complete; splendid condition. Can be seen working. Change in motive power only reason for sale.—Address Box W. 10, SHEFFIELD DAILY INDEPENDENT, 21, Fargate, Sheffield.

MESSRS. C. A. ROBINSON & CO., Anchor Iron Wharf, East Greenwich, S.E., are Cash Buyers of every description of Scrap Iron and Steel, Brass, Copper, and all Metallic Residues. Telephone, 94 Deptford.

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ALSO SOLE MANUFACTURERS OF

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Specially prepared for Bessemer, Siemens, and Crucible Steel Castings, Cores, &c.

NEEPSEND, SHEFFIELD.

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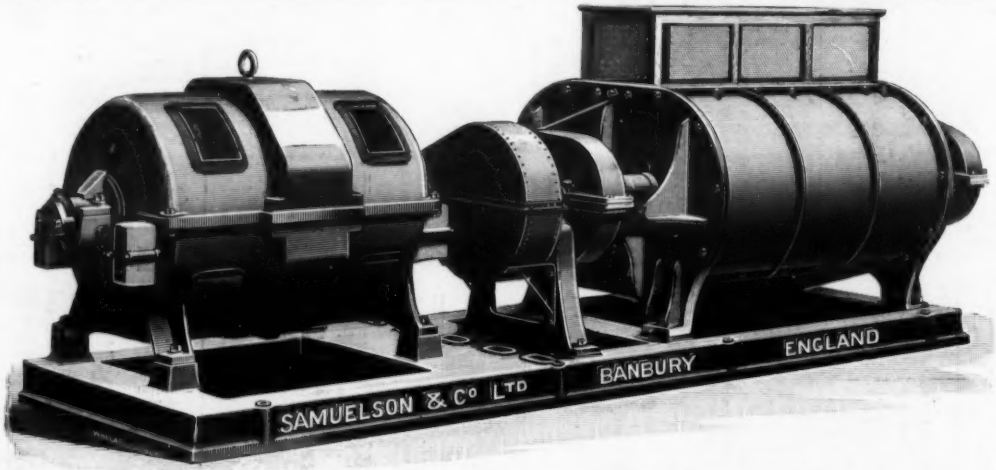
CONTRACTORS TO THE ADMIRALTY WAR OFFICE, COLONIAL & FOREIGN GOVERNMENTS.

For Ordinary or High Pressures up to 10 lbs. per square inch.



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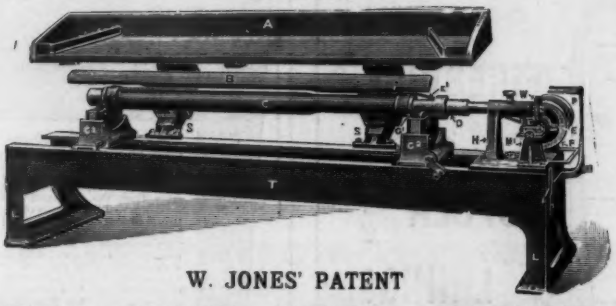

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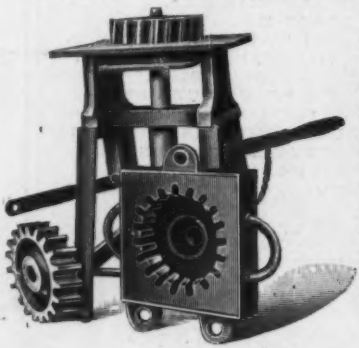

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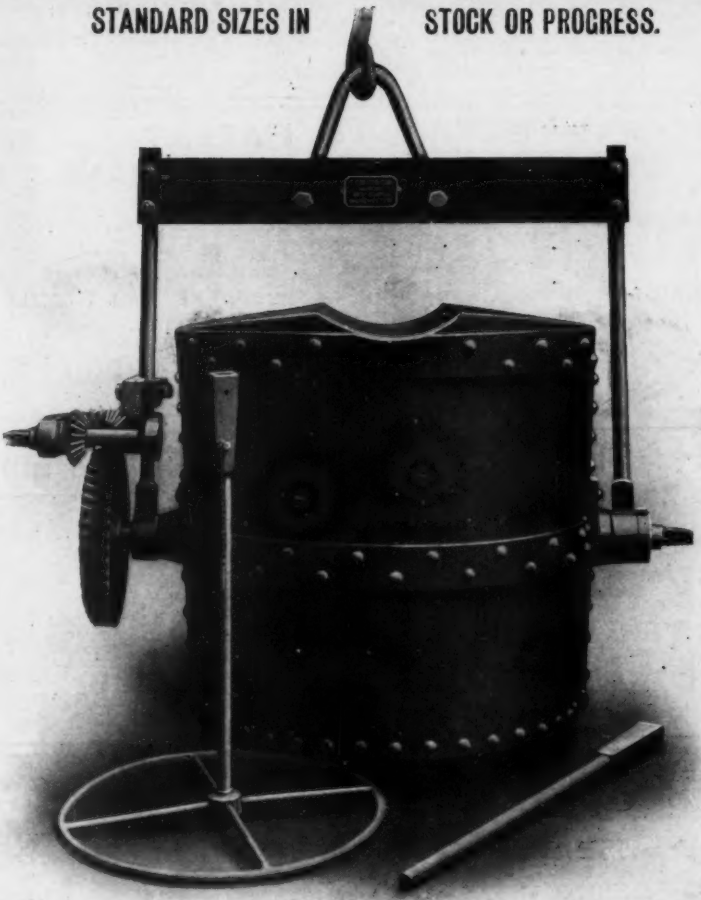

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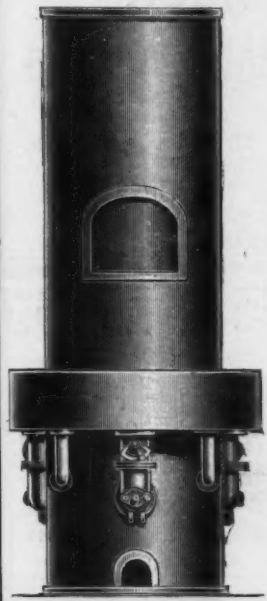

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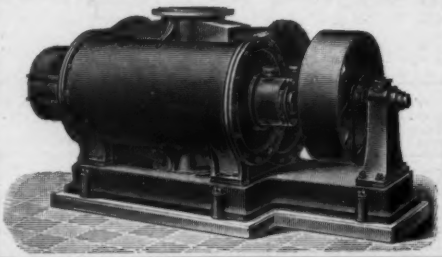

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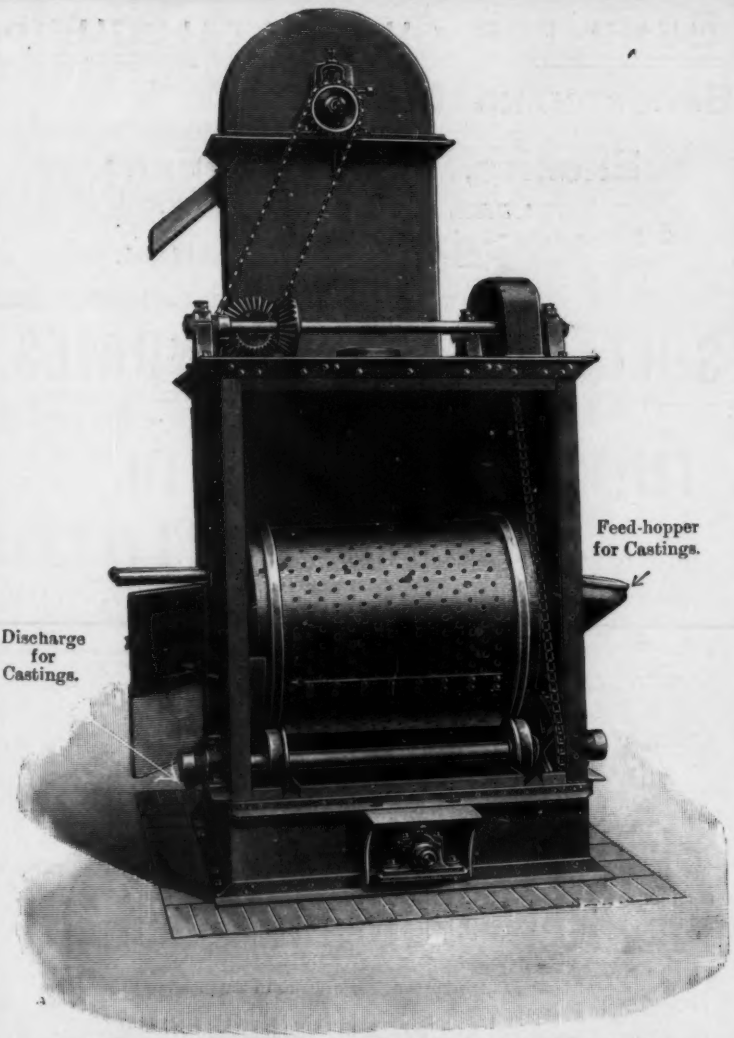

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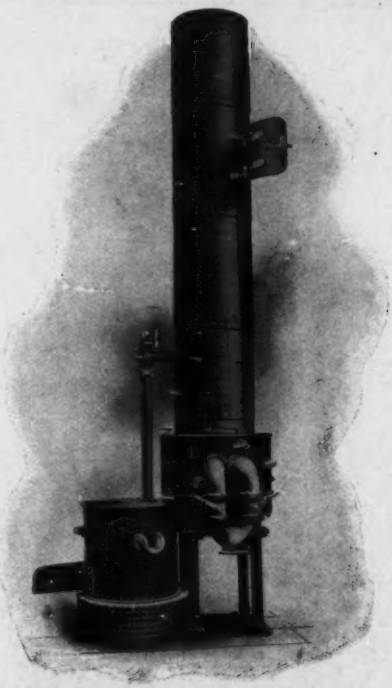

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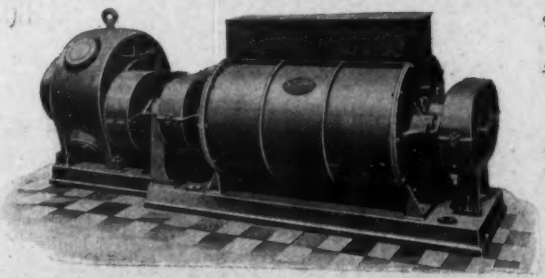

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